Central Great Plains Research Station

2000 Research Progress Report

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USDA ARS NRCS Colorado State University

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CENTRAL PLAINS RESOURCES MANAGEMENT RESEARCH UNIT

MISSION STATEMENT

To enhance the economic and environmental well-being of agriculture by development of integrated cropping systems and technologies for optimal utilization of soil and water resources. Emphasis is on efficient use of plant nutrients, pesticides, and water and soil conservation/preservation.

CENTRAL GREAT PLAINS RESEARCH STATION STAFF

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SUMMARY OF 2000 WEATHER

CENTRAL GREAT PLAINS RESEARCH STATION
AKRON, COLORADO

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There were four main features of the **Year-2000** weather year, namely: **1)** the continuation of the warm, open winter; **2)** the drought conditions during the normally wet, spring months; **3)** the intense and prolonged heat during the summer months; and **4)** the return of cold, early winter conditions.

The mild, warm winter, supposedly a result of the "La Niña" conditions, continued through the winter and early spring of 2000. The main contrast with previous "La Niña" conditions is that the spring months turned out to be extremely dry. The monthly total rainfall for the three months of **April, May, and June** ranked as the **second driest** for this period of the 93-year record. This had serious and severe ramifications for the winter wheat crop and for spring planted summer crops and pastures. In addition, the summer temperatures were much hotter. In fact, the summer of 2000 ranked among the hottest summers on record in several yardstick categories.

TEMPERATURES

Monthly mean, maximum, and minimum temperatures are shown in Tables 1, 2, and 3 (see also the graph of the Monthly Mean temperatures). The warm trend continued to carry over from the 1999 fall and early winter. The last month of below average mean temperature was September 1999. This trend continued until Oct. 2000, which was 0.09 degrees below average and changed drastically in **Nov. 2000**, which averaged **8.65 ° F** below the long-term average. The change in November 2000 was the most significant cooling period since the early winter of 1998. **November 2000** brought the first below zero temperature since Dec. 1998, and ranked as the **third coldest November** of the 90-year record.

The mid-winter months of January and February were extremely warm and mild. The February average maximum was 9.17 ° F above average. A new long-term record high minimum temperature of only 39 ° F was set on the morning of Feb. 15. The warm and mild trend continued into March and April. There was a short cold period on April 16, with two new record lows set, a low maximum of 25 and a low minimum of 15. The change to a warm period was emphasized with a tie of the record daily maximum of 86 ° F on the 19th.

The month of May brought continued warming with a new record maximum and minimum of 90 and 52 ° F on May 5th. A **damaging freeze** of **24 ° F** occurred on **May 13th**. This caused widespread damage to winter wheat, since the development of the crop was considerably ahead of schedule as a result of the warm early spring temperatures, and early termination of winter dormancy. New record high temperatures were again set in late May, with a high minimum of 58 ° F on the 29th, and a tie of the record maximum for the month, of 97 ° F, on the 30th.

This early heating in May was only a harbinger of things to come. New record daily

maximums of 99 and 101 ° F were set on June 7 and 8. This started a summer heating event that had not occurred for several years.

The **May through September** summer period brought heating that ranked **6th** over-all in **average maximum temperature**, and **13th** hottest in **average mean temperature**. However, the intense heat of 2000 ranked **third** in the **number of days of 90 ° F or greater maximums**, with **73** days. This compares to the record of 77 days in 1939 and **76** days in 1934 (see Table 4). This total also includes five days of 100 ° F or greater. While the daily maximums were quite high, the **daily minimums** were relatively mild, with an average of 51.14 ° F, which ranked only in **43rd** place of the warmest minimums. In terms of **consecutive days of 90 ° F or greater maximums**, the summer of 2000 had periods of 17, 10, and 7 days. While this was not a record (21 days in 1939), it was a relatively uncomfortable summer, when compared to recent years.

The summer heat continued well into September with new daily record maximums of 97 and 98 ° F set on Sept. 17 and 18, and a record high minimum of 60 ° F on the 18th. The summer heating ended abruptly by Sept. 23, with snow and the first hard freeze. In fact, new record low maximums of 46, 33, and 36 ° F were set on the 23rd, 24th, and 25th. The cooling trend continued into October, which turned out to be the first month since Sept. 1999, with a below-average mean temperature. New record daily minimum temperatures were set in the Oct. 8 - 10 period. Mild temperatures returned near the end of the month, with several days of warm rainy weather.

The month of November, as stated earlier, brought the most significant end to the long heating period. The highest maximum temperature for the month was a 60 ° F on Nov. 5. There were only four other days in the month with temperatures greater than 50 ° F. The average November maximum ranked as the **4th** coldest on record, and the average minimum ranked as the **2nd** coldest. The December temperatures continued to be colder than in recent years, but more similar to "normal" winter conditions of the past.

The ***average annual mean temperature*** (an average of the daily mean for the 366 days of the year) as shown in the **"Annual Mean Temp."** graph, was **49.87 ° F**. This ranks **2000** as the **15th** warmest year on record. In comparison, the warmest year was 1934, with an average annual mean temperature of 52.64 ° F, and the coldest year was 1912 with an average of 44.81 ° F

A summary of the **Growing-Degree-Days (GDD)** for the summer months is shown in Table 4. The final **GDD** total was **11.7%** above the average. This ranks as the **10th highest GDD** accumulation of the 93-year record.

PRECIPITATION

The **annual total precipitation for 2000** was **14.30 inches,** which ranks as the **66th wettest** or the **28th driest** of the 93-year record. The **May-Sept. period** total was only **7.89 inches,** or only **68.7 %** of the average for this period, and also only **55.2%** of the total annual precipitation. The average percent of the annual total for this period is 69.4%. The **April-May-June** precipitation was only **2.68 inches** and ranks second to 1998 with 2.12 inches, for the **driest April-May-June** period on record. The average for this period is 7.10 inches.

While January and February were only slightly below average to average in precipitation, the month of March brought prospects of a more "normal" spring, with two significant rain/snow

events during the month. A mixed rain and snow of 1.23 inches on March 7th, and a wet snow on March 30th pushed March to 1.42 inches above the average. The dry April-May-June period took its toll on the winter wheat crop. The wheat crop had been benefiting from early fall moisture in 1999, and with the mild winter, had broken dormancy earlier, and had lush growth by this time. By late May, the wheat crop was showing considerable stress due to the low rainfall and warm temperatures that enhanced water use. In addition, some wheat was damaged by a hard freeze on May 13th.

A series of **tornadoes** moved just south of the Research Station between 12:30 PM and 1:30 PM on May 17th. Some relatively minor damage was done by the tornadoes, as they moved from east to west, toward the town of Akron. Although the skies were threatening and dark, there was very little precipitation with this event.

The month of July brought the first near average rainfall of 2.69 inches for the month. In addition some hail did occur, but possibly not as widespread and severe as in 1999. A significant hail at the Research Station, occurred on July 21, with ¾-inch diameter hail. The first significant rainfall of the season did not occur until late September, with 1.41 inches of rain after Sept. 20. A warm rain of 0.94 inches occurred on Sept. 19, with wet snow on Sept. 23. October brought similar conditions with drizzle and significant rain during the Oct. 22-24 period, and again on Oct. 29-30. The November-December period brought more typical winter period, in contrast to the last few years, with near normal snow/rain conditions and below average cold temperatures. Total snowfall was somewhat below the rough average of about 30 inches per year, with only a total of **19.5 inches** for the calendar year, spread over two separate winter seasons (**see Table 6**.).

The following tables and graphs show other features of the ***2000 weather year****, and compare the* ***2000 season*** *with the long-term record. This completes the* ***93rd year*** *of compilation of daily rainfall and temperature records at the Research Station.*

TABLE 1. AVERAGE MONTHLY MEAN TEMPERATURES
(Based on 8:00 am daily observation time)

2 0 0 0 TEMPERATURES

USDA-ARS RESEARCH STATION, AKRON, CO

MEAN TEMPS

MONTH	2000 AVERAGE	93-YEAR 1908-00 AVERAGE	DEPARTURE	HIGH AVERAGE	(YEAR)	LOW AVERAGE	(YEAR)
JAN	30.69 °F	25.30 °F	5.40 °F	35.4	(1986)	7.8	(1937)
FEB	36.72	30.06	6.67	41.1	(1954)	16.0	(1929)
MAR	40.15	36.44	3.70	45.5	(1986)	19.9	(1912)
APR	47.75	46.43	1.32	53.6	(1930)	35.9	(1920)
MAY	59.23	56.25	2.98	65.3	(1934)	48.0	(1995)
JUN	66.67	66.54	0.13	73.5	(1956)	59.1	(1945)
JUL	75.53	73.33	2.20	79.9	(1934)	67.6	(1915)
AUG	74.84	71.49	3.35	77.0	(1983)	65.3	(1927)
SEP	62.73	62.32	0.41	68.4	(1998)	53.8	(1965)
OCT	50.24	50.33	-0.09	59.0	(1963)	40.7	(1969)
NOV	27.98	36.63	-8.65	45.8	(1949)	23.5	(1929)
DEC	25.85	27.57	-1.72	36.3	(1980)	12.7	(1983)
YEARLY AVE MEAN TEMP	49.866 °F	48.5575 °F	1.308 °F	52.64	(1934)	44.81	(1912)

ALL TEMPERATURES IN DEGREES F

2000 DATA INCLUDED IN AVERAGES

MAX TEMPS

TABLE 2. AVERAGE MONTHLY MAXIMUM TEMPERATURES

JAN	43.61 °F	38.02 °F	5.60 °F	49.6	(1934)	20.8	(1937)
FEB	51.93	42.87	9.06	56.0	(1954)	28.6	(1929)
MAR	53.35	49.74	3.61	60.6	(1972)	28.7	(1912)
APR	65.60	60.50	5.10	69.9	(1908)	45.7	(1920)
MAY	75.68	70.05	5.63	81.9	(1934)	57.5	(1995)
JUN	83.57	81.30	2.27	89.6	(1952)	70.0	(1928)
JUL	92.00	88.76	3.24	97.6	(1934)	81.2	(1915)
AUG	92.03	86.85	5.18	93.8	(1937)	77.5	(1927)
SEP	79.00	77.96	1.04	85.8	(1998)	65.6	(1965)
OCT	65.39	65.80	-0.42	75.1	(1963)	50.8	(1969)
NOV	39.93	50.32	-10.39	62.2	(1949)	33.0	(1929)
DEC	39.42	40.15	-0.73	51.6	(1957)	22.4	(1983)
YEARLY AVE MAX TEMP	65.126 °F	62.693 °F	2.433 °F				

MIN TEMPS

TABLE 3. AVERAGE MONTHLY MINIMUM TEMPERATURES

JAN	17.77 °F	12.58 °F	5.20 °F	22.9	(1953)	-5.3	(1937)
FEB	21.52	17.24	4.28	26.6	(1992)	2.2	(1936)
MAR	26.94	23.15	3.79	30.9	(1986)	11.0	(1912)
APR	29.90	32.36	-2.46	39.3	(1930)	26.1	(1920)
MAY	42.77	42.44	0.33	48.6	(1934)	36.5	(1917)
JUN	49.77	51.78	-2.01	57.7	(1956)	46.0	(1945)
JUL	59.06	57.91	1.15	62.6	(1966)	54.1	(1915)
AUG	57.65	56.13	1.52	60.8	(1983)	52.2	(20&74)
SEP	46.47	46.68	-0.22	52.6	(1963)	41.2	(12&45)
OCT	35.10	34.85	0.24	43.0	(1963)	28.9	(1917)
NOV	16.03	22.94	-6.91	29.4	(1998)	14.0	(1929)
DEC	12.29	15.00	-2.71	21.9	(1946)	3.1	(1983)
YEARLY AVE MIN TEMP	34.605 °F	34.422 °F	0.183 °F				

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TABLE 4. SUMMER GROWING SEASON RAINFALL, TEMPERATURE, AND GROWING DEGREE-DAY SUMMARY FOR USDA-ARS RESEARCH STATION, AKRON, COLORADO [2000 & 93-AVERAGE]

RAINFALL inches			TEMPERATURE DATA MAY-SEPT. 2000									
			AVERAGE MEAN TEMP Deg F		GROWING DEGREE-DAYS**		NUMBER OF DAYS 90 or ABOVE; 100 or Above; 55 or BELOW					
							AKRON -- 2000			AKRON 93-YR AVE		
MONTH	2000*	AVG*	2000*	AVG*	2000*	AVG*	90+	100+	<55	90+	100+	<55
MAY	0.75	2.97	59.23	56.25	313.5	236.0	4	0	30	1.0	0.0	30.4
JUN	0.76	2.47	66.67	66.54	500.0	499.4	11	1	24	7.5	0.6	21.8
JUL	2.69	2.70	75.53	73.33	791.5	723.5	23	2	6	16.1	2.0	8.7
AUG	1.94	2.10	74.84	71.49	770.0	666.3	25	2	8	13.6	0.8	13.1
SEP	1.75	1.24	62.73	62.32	433.5	388.3	10	0	27	4.9	0.1	26.5
TOTALS	**7.89**	**11.48**	**67.84**	**65.99**	**2808.5**	**2513.6**	**73**	**5**	**95**	**43.0**	**3.5**	**100.6**

* 93-year average rainfall and temperature data(1908-2000): and number of days 90 or above, 100 or above, and 55 or less; at Central Great Plains Res. Sta., Akron, Colorado

** GROWING DEG-DAYS defined as number of days with daily mean temperature above a 50-degree F base. For example..Max = 85; Min = 53; Mean = (85+53)/2=69. Deg-Day unit = 69 - 50 = 19 GDD units.

AKRON GDD UNITS ACCUMULATED FROM MAY 1 THROUGH SEPT. 30.

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TABLE 5. RAINFALL AMOUNTS BY MONTHS. USDA-ARS, AKRON, COLORADO

(Based on 8:00 am daily observation time)

2 0 0 0 RAINFALL SUMMARY

MONTH	2000 TOTAL	93-YEAR AVE AVE. 1908-2000	DEPART.	% OF AVERAGE	HIGH TOTAL	(YEAR)	LOW TOTAL	(YEAR)	2000 CUM	93-YR AV CUM	DEPART. CUM	% OF AVERAGE	MON
JAN	0.23 inches	0.33 inches	-0.10	69.5%	1.51	(1988)	0.00	(6 YRS)	0.23	0.33	-0.10	69.5%	JAN
FEB	0.33	0.35	-0.02	95.3%	1.68	(1915)	0.00	(9 YRS)	0.56	0.68	-0.12	82.7%	FEB
MAR	2.25	0.83	1.42	269.8%	3.06	(1909)	0.00	(1908)	2.81	1.51	1.30	186.0%	MAR
APR	1.17	1.65	-0.48	70.8%	5.19	(1915)	0.17	(1928)	3.98	3.16	0.82	125.8%	APR
MAY	0.75	2.97	-2.22	25.2%	7.79	(1917)	0.13	(1974)	4.73	6.14	-1.41	77.1%	MAY
JUN	0.76	2.47	-1.71	30.7%	6.11	(1965)	0.19	(1952)	5.49	8.61	-3.12	63.8%	JUN
JUL	2.69	2.70	-0.01	99.7%	7.22	(1946)	0.31	(1934)	8.18	11.31	-3.13	72.3%	JUL
AUG	1.94	2.10	-0.16	92.4%	7.36	(1918)	0.16	(1973)	10.12	13.41	-3.29	75.5%	AUG
SEP	1.75	1.24	0.51	141.1%	4.83	(1950)	0.00	(1978)	11.87	14.65	-2.78	81.0%	SEP
OCT	1.74	0.91	0.83	190.6%	3.71	(1993)	0.00	(3 YRS)	13.61	15.56	-1.95	87.5%	OCT
NOV	0.47	0.56	-0.09	84.6%	2.67	(1946)	0.00	(3 YRS)	14.08	16.12	-2.04	87.4%	NOV
DEC	0.22	0.41	-0.19	53.5%	3.27	(1913)	0.00	(1908,28)	14.30	16.53	-2.23	86.5%	DEC
Total	14.30 inches	16.5280 inches	-2.23	86.5%	26.79	(1946)	9.93	(1939,74)	14.30	16.53	-2.23	86.5%	

LAST UPDATE>> 10-Jan-2001

2000 date included in average

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Table 6. Snowfall Dates and Depths for Calendar Year 2000
USDA-ARS Research Station, Akron, Colorado

DATE	Snow Depth inches	Precipitation inches
Jan. 3-4	2.00	0.15
Jan. 11	Trace	Trace
Jan. 27 - 30	0.50	0.08
Feb. 10 - 11	0.50	0.07
Feb. 27 - 28	2.00	0.26
Mar. 2 - 3	Trace	0.18
Mar. 8	2.00	1.23
Mar. 10	Trace	0.04
Mar. 16	0.50	0.09
Mar. 18	Trace	Trace
Mar. 21 - 22	0.50	0.20
Mar. 31	5.00	0.51
April 1 - 3	Trace	0.14
Sub-Total	**13.00**	**2.95**
Sept. 24 - 25	1.50	0.25
Oct. 6	Trace	Trace
Nov. 6	1.50	0.15
Nov. 11 - 13	1.00	0.15
Nov. 16	Trace	Trace
Dec. 6	Trace	0.07
Dec. 10 - 14	Trace	Trace
Dec. 21	Trace	Trace
Dec. 25-26	Trace	Trace
Dec. 31	2.50	0.15
Sub-Total	**6.50**	**0.77**
TOTALS	**19.50**	**3.72**

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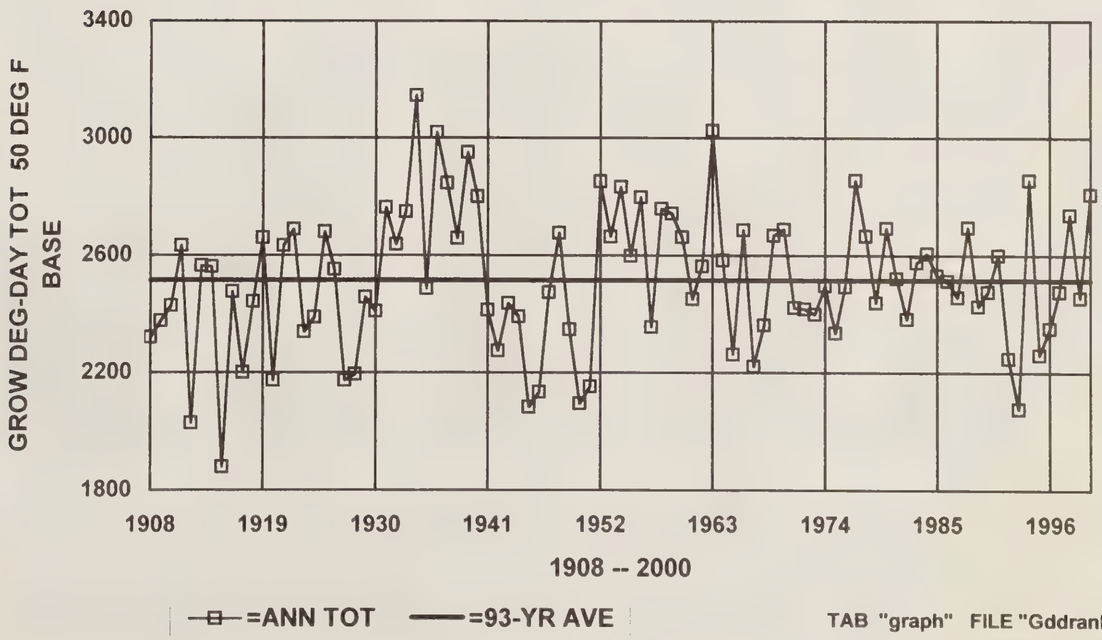
GROWING DEGREE-DAYS (MAY-SEPT)
USDA-ARS RESEARCH STATION, AKRON, CO



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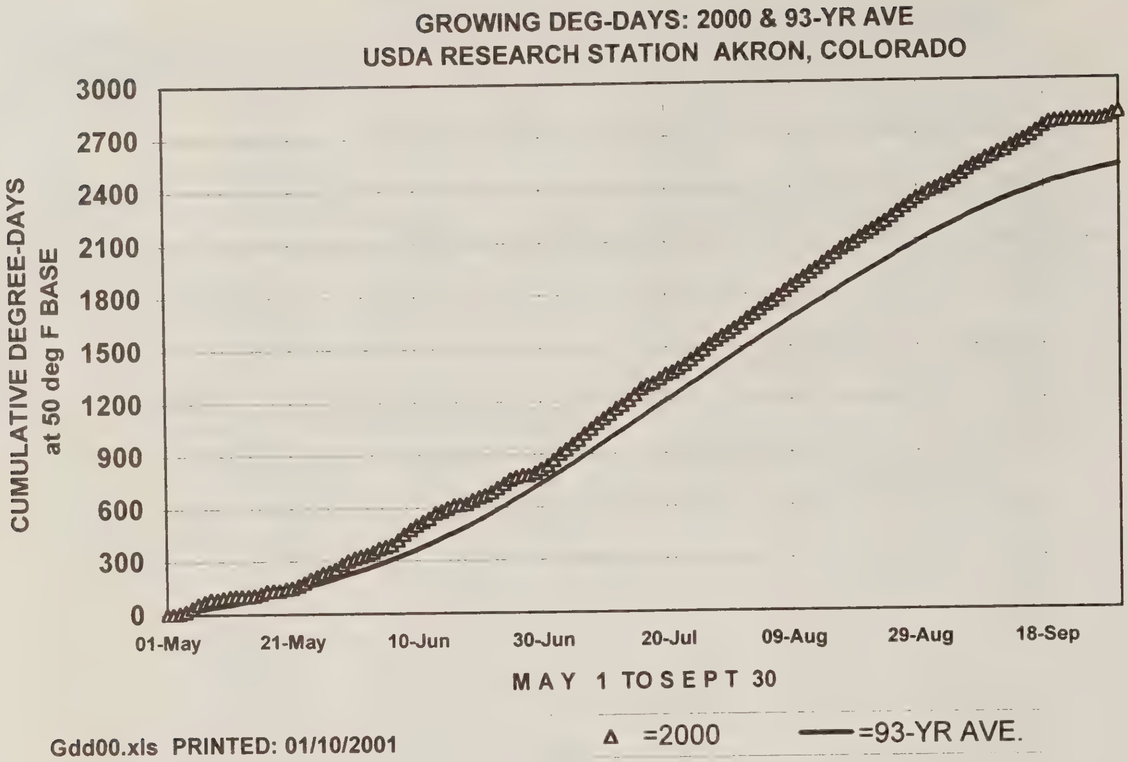
GROWING DEG-DAYS: 2000 & 93-YR AVE
USDA RESEARCH STATION AKRON, COLORADO
CUMULATIVE DEGREE-DAYS at 50 deg F BASE
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
01-May
21-May
10-Jun
30-Jun
20-Jul
09-Aug
29-Aug
18-Sep
MAY 1 TO SEPT 30
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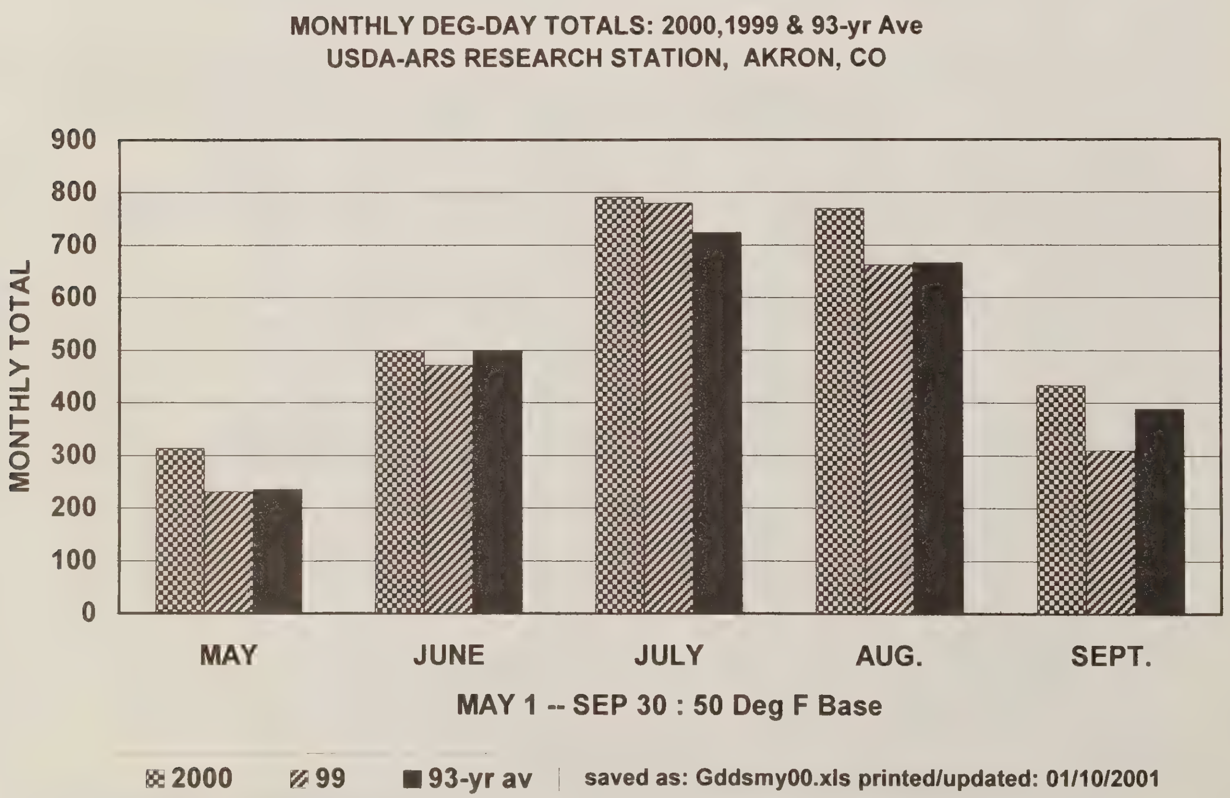
=2000
=93-YR AVE.


MONTHLY DEG-DAY TOTALS: 2000,1999 & 93-yr Ave
USDA-ARS RESEARCH STATION, AKRON, CO
MONTHLY TOTAL
900
800
700
600
500
400
300
200
100
0
MAY
JUNE
JULY
AUG.
SEPT.
MAY 1 -- SEP 30 : 50 Deg F Base
2000
99
93-yr av
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2000 RAINFALL

CENTRAL GREAT PLAINS RESEARCH STATION AKRON, COLORADO
PRECIPITATION LOG 2000 STANDARD GUAGE inches LOCATION: WEATHER STATION

[Rainfall amounts are for the period 12:00 midnight to 12:00 midnight for the date recorded.]

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1				0.03									1
2	0.03		0.18	0.01									2
3	0.12			0.02			0.13						3
4								0.49	0.17				4
5								T		T	0.15		5
6											T	0.07	6
7			0.59										7
8			0.64		0.12								8
9			0.04		T		T						9
10	T	0.02					0.20					T	10
11		0.05									0.07	T	11
12							0.28				0.08		12
13						0.01						T	13
14				T								T	14
15			0.09	T				0.07			T		15
16						0.14	0.01	0.23					16
17		0.24	T		0.06	0.48	1.28						17
18		0.02			0.27								18
19									0.70				19
20			0.05		T		0.57	0.05	0.24			T	20
21			0.15				0.09		0.17				21
22		T	T	0.06					0.03	0.78			22
23									0.09	0.05			23
24		T	T	0.07	0.02				0.18	0.03		T	24
25					0.13	T						T	25
26					0.12	T	T	0.61					26
27	0.05				0.03	0.13	0.13	0.38					27
28								0.11		0.65			28
29	0.03			0.45						0.23		0.12	29
30			0.12	0.45								0.03	30
31			0.47					0.17		0.17			31

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
SUM	0.23	0.33	2.33	1.09	0.75	0.76	2.69	2.11	1.58	1.91	0.30	0.22	MONTHLY TOTAL
AVE	0.33	0.35	0.83	1.65	2.97	2.47	2.70	2.10	1.24	0.91	0.55	0.41	<<93-YEAR AVE
DEP	-0.10	-0.02	1.50	-0.56	-2.22	-1.71	-0.01	0.01	0.34	1.00	-0.25	-0.19	DEPARTURE
%NORM	69.5%	95.3%	279.1%	66.0%	25.2%	30.7%	99.7%	100.4%	127.6%	208.8%	54.2%	53.5%	MONTHLY % OF NORMAL
CUM	0.23	0.56	2.89	3.98	4.73	5.49	8.18	10.29	11.87	13.78	14.08	14.30	CURRENT ACUM
AVCM	0.33	0.68	1.51	3.16	6.14	8.61	11.31	13.41	14.65	15.56	16.12	16.53	AVE ACUM
DEP	-0.10	-0.12	1.38	0.82	-1.41	-3.12	-3.13	-3.12	-2.78	-1.78	-2.04	-2.23	DEPARTURE
%of NORM	69.5%	82.7%	191.2%	125.8%	77.1%	63.8%	72.3%	76.7%	81.0%	88.5%	87.4%	86.5%	CUM % OF NORM

LAST UPDATE>> 10-Jan-01

NOTE: NEW MONTHLY AVERAGE IS CALCULATED.......NEW AVERAGE INCLUDES 2000 RAINFALL DATA

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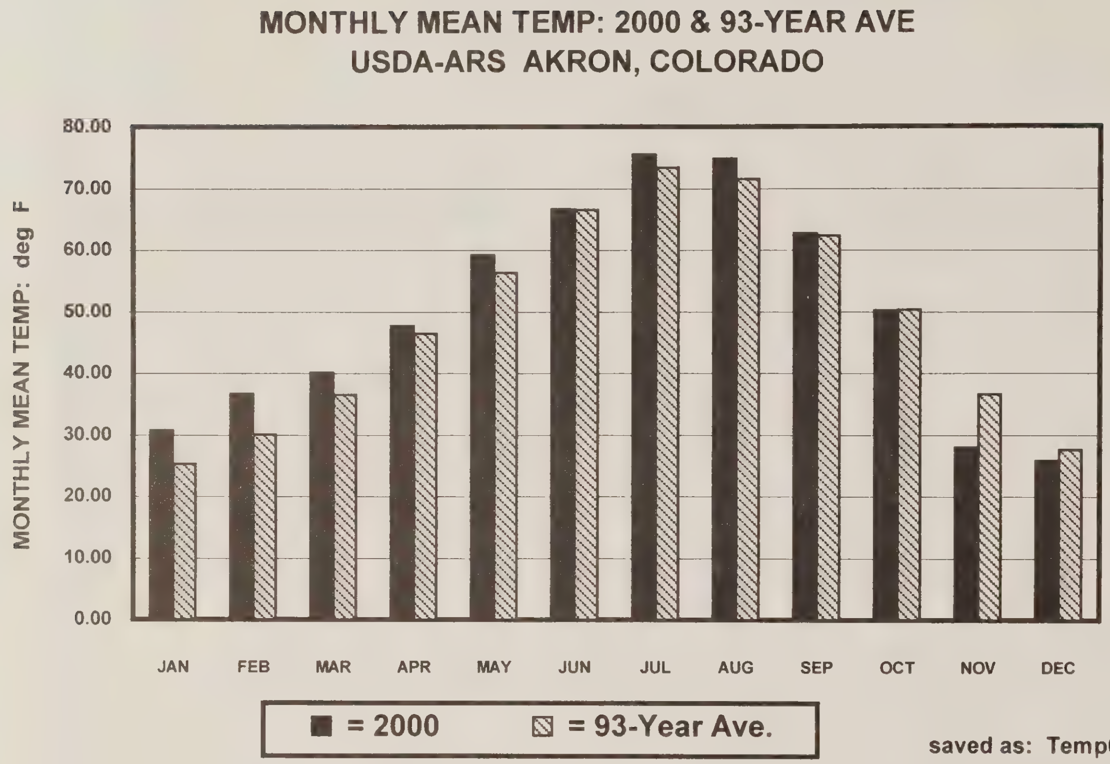

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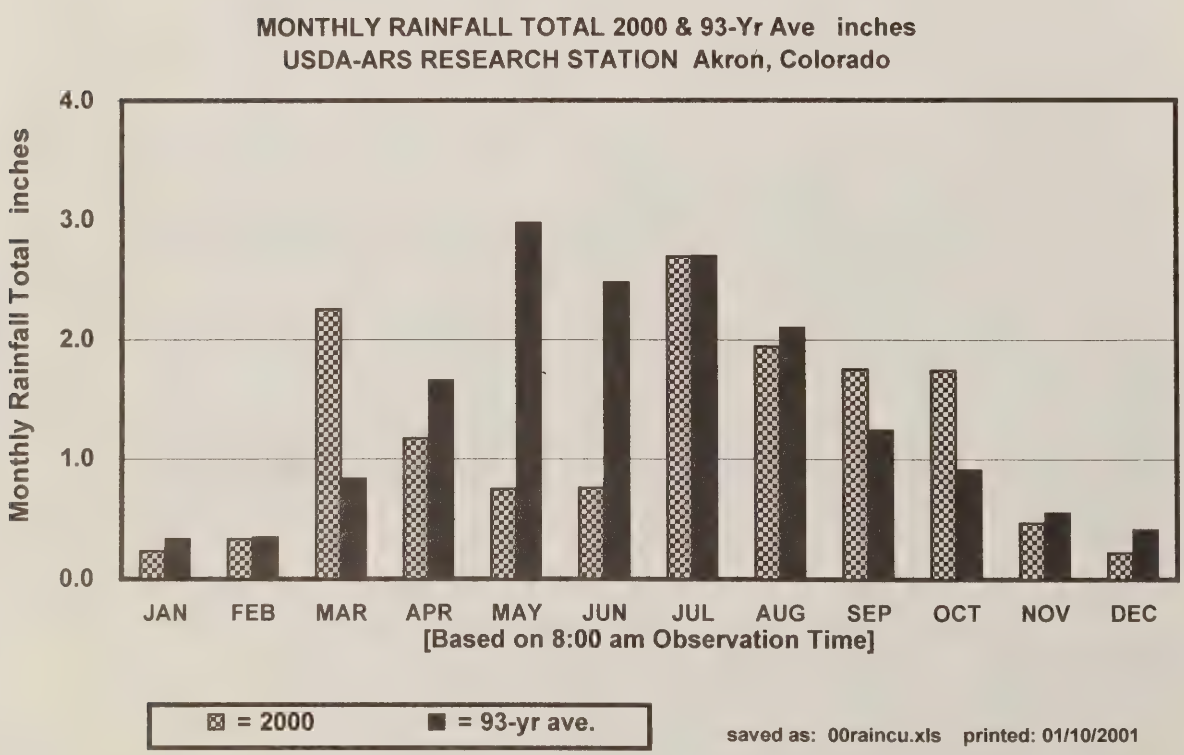

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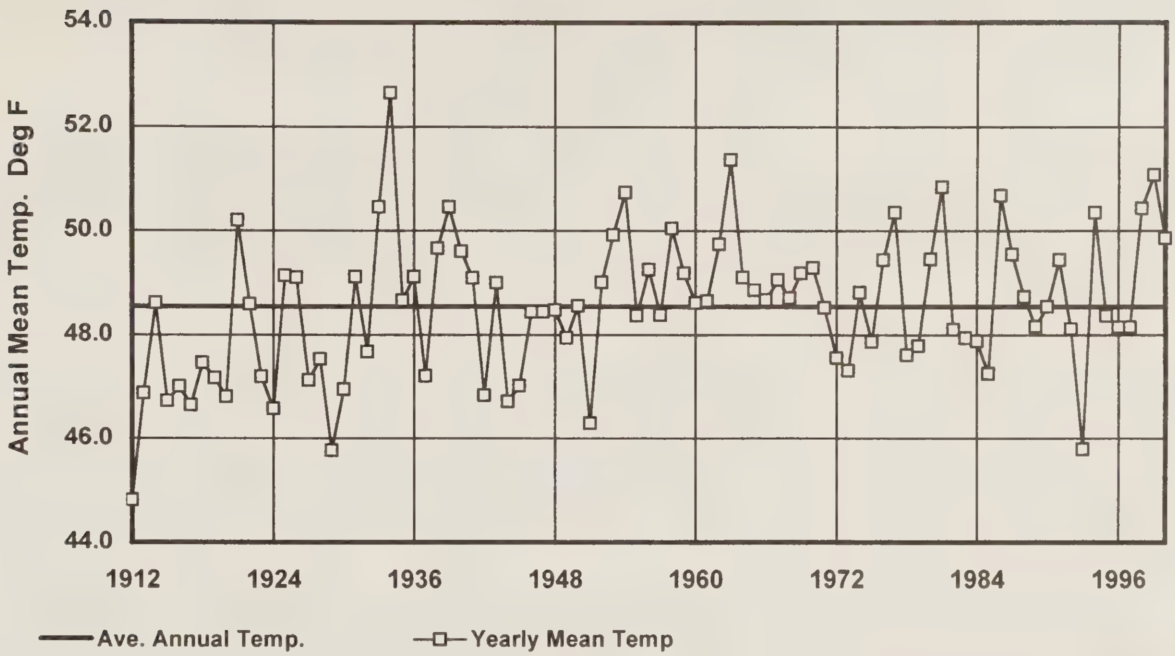
ANNUAL MEAN TEMP. Deg F
USDA-ARS Research Station, Akron, Colorado



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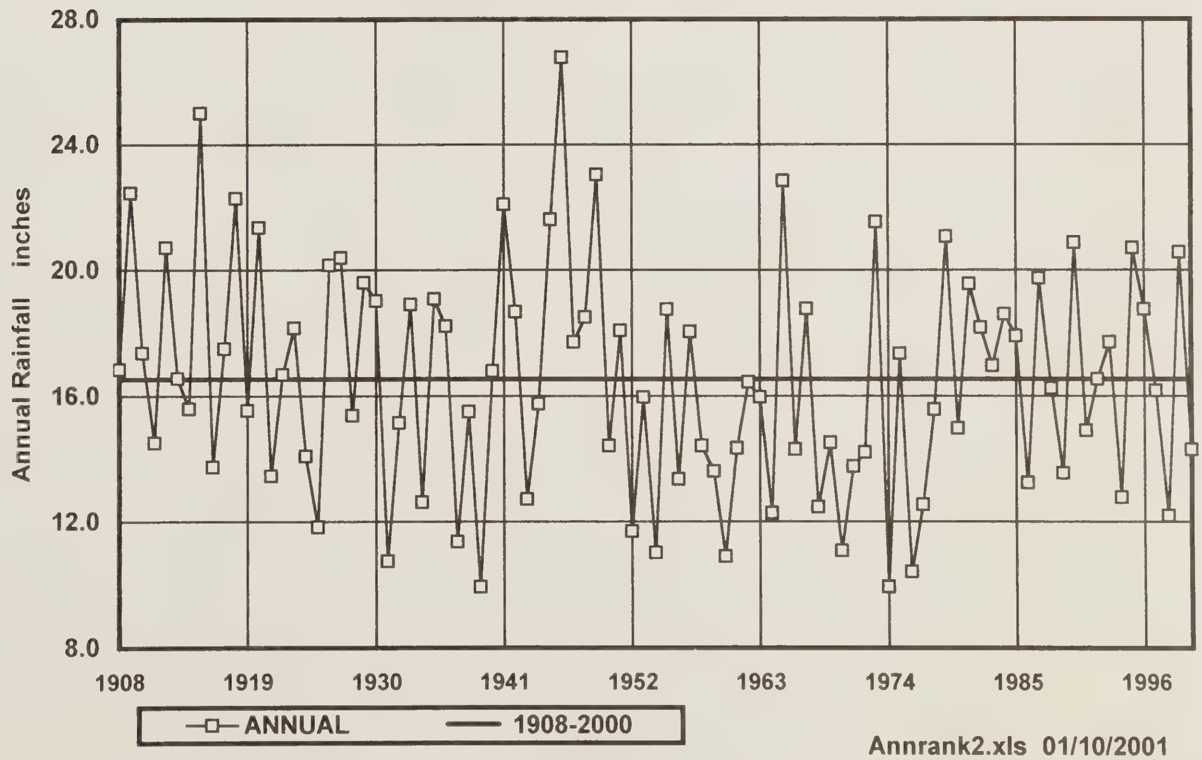
ANNUAL TOTAL RAINFALL 1908-2000
USDA-ARS Research Station, Akron, Colorado



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ESTIMATING SOIL HYDRAULIC PROPERTIES FROM SPARSE DATA

J.G. Benjamin

PROBLEM: Determining soil water characteristics is both laborious and time-consuming, but is necessary for many soil management evaluations and for modeling purposes. Methods need to be developed that give the required information about soil hydraulic conductivity and water retention characteristics but do not need the tedious laboratory or field sampling procedures that are used with current methods.

APPROACH: We used an adaptation of the Gregson-Hector-McGowan (GHM) model of water retention. The GHM model uses information about the relationship between the slope and intercept of a log-log plot of the $\psi(\theta)$ curve to improve predictions of soil water retention characteristics from limited data. Studies have shown that using this method and one $\psi(\theta)$ point can give very good predictions of the entire $\psi(\theta)$ curve. We used an analogous procedure to determine coefficients for unsaturated hydraulic conductivity function based on the slope and intercept of a log-log plot of the $k(\theta)$ curve. The GHM model was fit to $k(\theta)$ data, determined on soil cores by the step outflow method, for 9 medium to fine textured soils from Ohio, Iowa and Colorado. The soils came from various rotation and tillage studies showing a range of hydraulic properties. We used the $k(\theta)$ data from the -33 kPa ψ as the fitting point. Predictions were made from the GHM regression on individual soil cores, from the GHM method using slope-intercept relations for individual soils and from the GHM method using slope-intercept relations for all soils. We computed the coefficients on each soil core for the van Genuchten - Maulem (VGM) equation of hydraulic conductivity to compare the accuracy of the GHM method and a standard model often used in modeling.

RESULTS: A strong correlation ($r^2 > 0.9$) was found between the slope and intercept of individual log-log plots of both the $\psi(\theta)$ and $K(\theta)$ curves. Predictions of the $\psi(\theta)$ curve using the GHM model had about twice the error as using the van Genuchten (VG) model on individual soil cores. This accuracy may be sufficient for many purposes, considering only the knowledge of one $\psi(\theta)$ point is needed. The GHM method, using a known, unsaturated, $K(\theta)$ point had lower errors for the predicted $K(\theta)$ curve than the VGM method of determining unsaturated hydraulic from a pore size distribution function and a saturated $K(\theta)$ data point. There was a low correlation between the coefficients of the $\psi(\theta)$ and $K(\theta)$ curves for the GHM model, indicating that changes in pore continuity or tortuosity, as well as pore sizes, are influencing K.

FUTURE PLANS: Hydraulic conductivity and water retention characteristics are measured on soils from other studies as a means to determine soil management effects on the plant root environment. We plan to continue the evaluation of this technique to determine under what soil conditions and management schemes the procedure is valid and under what conditions the procedure fails to give acceptable estimates of water content and hydraulic conductivity.

MANAGING SOIL COMPACTION TO ENHANCE CORN PRODUCTION AND SOIL BIOLOGICAL ACTIVITY

J.G. Benjamin, M.F. Vigil, D.C. Nielsen

PROBLEM: Sustainability of agriculture demands that soil resources remain productive. Degradation of soil resources is of particular interest in the Great Plains because relatively low soil organic matter levels make these soils very susceptible to many adverse soil management effects such as compaction. Most compaction research has addressed changes in soil physical characteristics, but less research has addressed the effects of these physical changes on plant productivity and biological activity. In order to manage compaction, we need information on the soil environment created by varying compaction levels and information on the compaction level tolerated by plants. The goals of this research include: 1) Evaluate current concepts of soil mechanics as related to soil compaction; 2) Gain information about the soil environment and plant response to soil environmental changes caused by compaction to further understand the interaction between the soil and the plant; and 3) Test the effectiveness and longevity of methods to alleviate soil compaction.

APPROACH: We continued a study of soil compaction effects on corn (*Zea mays*, L.) growth and soil biological activity at Akron, Colorado, on a Weld silt loam (fine smectic, mesic Aridic Paleustolls) that was started in 1997. The treatments include 3 levels of wheel traffic (0, 2, and 8 passes of a 7700 kg tractor) and 5 methods of compaction alleviation: 1) no alleviation from tillage; 2) shallow (20 cm deep) chisel plow tillage conducted only at the start of the experiment; 3) shallow chisel plow tillage conducted yearly during the experiment; 4) deep (45 cm deep) chisel plow tillage conducted only at the start of the experiment; and 5) deep chisel plow tillage conducted yearly during the experiment. The field was planted to corn in the spring and plant growth characteristics were measured throughout the growing season to determine compaction effects on corn productivity. We took soil samples in the fall after harvest to determine yearly changes in the soil physical properties (bulk density, soil strength, infiltration, and water retention characteristics) caused by compaction and compaction alleviation.

RESULTS: We found a significant effect from wheel traffic in samples collected before and after compaction in the fall of 1997. Bulk densities from the non-compacted soil were about 1.4, bulk densities from soil with 2 tractor passes were about 1.5 and bulk densities from soil with 8 tractor passes were about 1.6. Changes in bulk density due to wheel traffic were evident in the surface 1.5 to 17 cm depths. Compaction of the argillic horizon of the Weld soil was still apparent 2 years after compaction and show that natural alleviation may not be sufficient to reduce compaction effects in a short period of time. Corn yield differences due to compaction found in 1998 were not as apparent in 2000 showing that good crop and irrigation management can be effective to reduce detrimental effects of soil compaction.

FUTURE PLANS: We plan to alter the experiment to include an irrigation variable and a crop rotation variable. We will irrigate at full potential ET and a 75% potential ET to examine irrigation management effects on soil productivity. We will include a rotation of Corn-Dry Bean-Sunflower-Oat to study the effects of different crop species on changes in the soil environment.

EVALUATING SOIL ENVIRONMENT EFFECTS ON ROOT GROWTH FOR SELECTED LEGUMES GROWN IN THE CENTRAL GREAT PLAINS

J.G. Benjamin, D.C. Nielsen

PROBLEM: In recent years crop rotations in the central Great Plains have changed from wheat-fallow to wheat-(summer crop[s])-(fallow). The summer crop[s] have included combinations of various crops such as corn, proso millet for grain, foxtail millet for forage, and/or sunflower for various numbers of years. These rotations may or may not include a fallow period before planting back into wheat. Discussions with farmers in the area have shown the need for an economical legume species to be included in the rotations. Likely candidates for suitable legume species include soybean (either for seed or for forage), garbanzo bean and field pea. Little is known about the water requirements for these species in the semi-arid west, or how the species respond to water stress or other soil environmental factors.

APPROACH: We started an experiment to examine root growth of garbanzo bean, soybean and profi field pea under two water regimes in 2000. The two water regimes include the natural rainfall condition and a fully watered condition controlled by supplemental irrigation. Soil samples for root biomass of each species were collected at two times during the growing season, once at about the maximum of vegetative growth and once after flowering during seed set. The samples were collected in 9" (22.5 cm) depth intervals to a depth of 45" (112.5 cm) with a 3" (7.5 cm) diameter sampling tube directly beneath a plant. Three sub samples were taken for each site. There were three replications. The soil samples were weighed in the field and a moisture sample was removed for moisture and bulk density determination. The samples were washed to extract the roots with a semi-automatic root washing apparatus. The root samples were preserved in methanol until time for determination of length, area, and dry weight. Root sample length and area are being determined from a scan of a digital image using Sigma Scan image analysis software.

RESULTS: We are in the process of analyzing the root images. Results will be expressed in terms of total root length per unit area, root length density with depth and root mass per unit length. Combined with above-ground sampling already being taken, estimates of root/shoot ratios can be calculated. The moisture content and bulk density information will be used to calculate the least limiting water content range (a measure of soil physical quality) for the soil. We will then be able to evaluate root patterns for the different species as affected by the rooting environment.

FUTURE PLANS: We plan to continue the experiment in 2001. We will follow the same sampling scheme as in 2000. We hope to identify differences in rooting patterns among species in response to available water conditions. This information may help us identify species suited to the severe climate of the central Great Plains.

EVALUATING AND QUANTIFYING SOIL QUALITY AND PRODUCTIVITY FROM SELECTED SOIL PROPERTIES

R. A. Bowman

PROBLEM: In the semiarid areas of the Great Plains, continued clean-till wheat-fallow cultivation has resulted in significant losses of soil organic matter (SOM) because of wind erosion and decomposition. This loss of SOM results in a deterioration of soil quality and a reduction in crop productivity because of attendant losses in soil physical, chemical and biological properties such as rooting depth, water storage and soil aggregation. Factors influencing crop productivity such as pH, SOM, texture, CEC, aggregate stability, and rooting depth (depth of solum or depth to lime) need to be evaluated under similar precipitation conditions to understand more fully yield differences, especially for the same rotation where important soil factors may be spatially different. A need exists, therefore, to develop methodology to assess soil productivity changes using these important soil factors in the analysis.

APPROACH: The intent is to develop a quantitative index to assist in the prediction of soil quality and crop productivity. Index will integrate differences in SOM, pH, texture, CEC, and rooting profile. SOM, clay and silt, bulk density (BD) and depth to lime (solum) are measured for a stratification depth (0-2"), a fertility index depth (0-6"), and a 24" depth. Thus, a Soil Productivity Index (SPI) can be developed based on best correlations of the SPI with the various soil depths and properties. Additionally, a structural index (S_t) based on ratio of SOM % to clay+silt % is also assessed to determine potential for degradation. Indices for new crop rotations can then be compared to indices from the traditional winter wheat-summer fallow, or with soils from an adjacent native sod of the same soil series.

RESULTS: Structural index, and turbidity, two parameters which qualitatively assess soil stability and aggregation, were determined on selected soils from the ACR. Piere advocated an St value of 5 below which soils are easily degraded. All our cultivated soils were below thus value. The sod was about 7. Nine means it contained sufficient SOM for its clay and silt content. The role of iron oxides as cementing agents and calcium carbonate may attenuate this adverse effects of low SOM. Data for turbidity was too variable for any consistent trend to be seen with SOM content. Probably , we need to conduct this test with field clods and not screened soils. Optical densities for base-treated decalcified soils appears to give a measure of stabilized carbon, but more data are required with soils of varying SOM content, and with subsoils.

FUTURE PLANS: The correlation of many of the soil parameters other than SOM for an assessment of soil quality/productivity is low. The 0-2 inch depth will be used for short-term assessment of soil quality, and the 24-inch depth for potential soil productivity since this depth more accurately integrates the rooting depth for nutrients and water uptake. As before these measurements will be used for comparative purposes only to compare one rotation against another, or against the conventional-till W-F, or native sod.

SOIL ORGANIC MATTER CHANGES UNDER ALTERNATE CROPPING AND TILLAGE SYSTEMS

R. A. Bowman, M. F. Vigil, D. C. Nielsen, J. Benjamin

PROBLEM: Soil organic matter is important to hold the soil together, to easily infiltrate water, to reduce compaction, and to provide nutrients such as N, P, K, S, and micronutrients. However, the conversion of Great Plains grassland to clean-till small grain farmlands since the mid 19th century has resulted in extensive loss of the native SOM because of wind erosion and decomposition. On a global basis with about 40% more organic carbon residing in the SOM than in the terrestrial plant biomass, it is easy to see how the conversion of grassland to wheat-fallow could create over time a drop in crop production and a significant increase in global CO_2. On the other hand, if we intensify the cropping system over the WF, and minimize soil disturbance through less tillage, and if we manage water, fertilizer, and pests efficiently, we should be able to reverse SOM loss and increase soil productivity. Our objective, therefore, was to evaluate different cropping systems for their efficiency in water and nutrient use, minimal soil erosion, minimal chemical leaching, and organic matter buildup. This report focuses on changes in SOM.

APPROACH: The study is located at Akron CO on a predominantly Weld silt loam. Three replications of 60 combinations and permutations of cropping and rotation sequences exist (See report by Anderson, Nielsen, Bowman, and Vigil for treatments). Extensive sampling was conducted on all 180 sites for soluble (dichromate oxidation) and total SOM and POM and total organic C and N (C-N analyzer). Soil samples were collected at 0-2 inch, and at 2-6 inch depths for pH and nutrient stratification and for plow layer evaluations especially under the no-till conditions and mixing under conventional-till. Soil samples on different soil series were taken to 5 feet depth. Some measure of aggregate stability against wind erosion is assessed. Cumulative OM Index (COMI) and solum SOM will be assessed every 3 to 5 years.

RESULTS: New data showed the same past trends with more intensively cropped rotations with less fallow having more SOM content. The nature of the SOM in the ACR was qualitatively evaluated by extraction of the carbon with acid followed by base. The E4:E6 ratio and OD at 280 (uv) were assessed to determine relative stability of the carbon among selected rotations, a lower ratio indicating higher molecular weight compounds, and the uv values inversely correlated with labile C and N compounds. The E4:E6 ratios for the rotations were of the order: sod < 3 and 4-yr rotations < wheat-fallow, conventional till. This indicates less humified C in the W-F rotation relative to the other rotations. The OD-280 showed lower absorbance with the W-F rotations indicating greater labile C and N relative to other rotations, but about equal absorbance for the other rotations and the sod.

FUTURE PLANS: Since rotations have been established for over 8 years, we will continue to assess in more intensively cropped rotations, stabilized or humic carbon for losses or gains relative to the conventional winter wheat-fallow rotation which receives less carbon inputs. The relationship between surface crop residue and roots to six inches relative to SOC and POM-C will also be investigated.

NUTRIENT, CEC, AND pH CHANGES UNDER ALTERNATE CROPPING SYSTEMS

R. A. Bowman, M. F. Vigil

PROBLEM: No-till systems usually conserve more moisture than clean-till systems, especially when weeds have been controlled. The extra available water invariably results in greater yield benefits from N and P fertilizer, with corn requiring more water and fertilizer than wheat because of its higher dry matter production (50 bushel dryland wheat requiring about 75 kg N and about 12 kg P, with 80 bushel dryland corn requiring about 80 kg N and 18 kg P / ha). The role of water and nitrogen is being studied for efficient use. As cropping continues, other nutrients such as P and micronutrients which are seldom replenished, may become deficient. This need becomes even greater in the eroded areas of the Plains where P is chemically fixed by free lime, and where high P applications may also induce Zn and Fe deficiencies. The objectives of the research, therefore, are to evaluate nutrient availability and cycling under WF and alternate cropping systems where more residue is returned to the soil surface, and consequently, more nutrients recycled from within the soil profile. Information is needed for P, S, and Zn use efficiency for subsequent crops such as corn and millet or oil crops or legumes after wheat in a reduced-till rotation.

APPROACH: In a Weld silt loam, various nutrient parameters were measured at the 0-2, 2-6 and 6-12 inch depths to assess availability and cycling in selected plots from our alternate cropping and tillage system study (ACR). These parameters included available P pools such as those extracted by bicarbonate and anion-exchange resins, total soil P, and total soil organic P, residual P and phosphatase activity which is a measure of quickly available organic P. Available S and micronutrients were also evaluated in the surface 6 inch. Because of yearly N applications in continuous cropping systems, pH and CEC changes were also assessed. We also are assessing S levels because of our oil crops, and Zn because of corn.

RESULTS: We are continuing to evaluate these nutrients in the ACR plots. We also seeded an area with varying fertility levels with spring wheat, profi peas, hairy vetch, and cicer milkvetch. Half the plot received sulfur (all received sufficient N). While spatial variability generally still was a more dominant factor, in these preliminary results, profi peas responded to S treatments where the soil fertility was low in the highly eroded areas. In the better fertility areas (no erosion or minimal erosion), the nitrate gave a better response. Germination of cicer milkvetch was slow, and this created a weed problem afterwards. Hairy milkvetch did not show any preferential response to sulfate or nitrate.

FUTURE PLANS: We will continue the above study to determine the need for S. We will continue to monitor nutrient data on ACR plots since we are only resupplying N and P. Role of residue in buffering pH changes (cation production), and in resupplying the other nutrients are still factors for future considerations. We will also monitor some of the soil S levels in Vigil's research plots with wheat, proso millet, and sunflower treatments. This was not done last year because of technician's transfer, and previous commitment to sample soils from a long-term cropping system in North Platte for soil organic carbon changes.

SOIL ORGANIC CARBON SPATIAL VARIABILITY AND CARBON SEQUESTRATION

R. A. Bowman, J. D. Reeder[1], B. J. Wienhold[2]

PROBLEM: Reliable quantification of soil organic carbon (SOC) is necessary if we are to reward good stewardship and conservation through carbon credits, and to assess our potential to meet the conditions of the **Kyoto Protocol** (7% reduction from 1990 levels of greenhouse gases between 2008 and 2012). Besides the benefits of reducing erosion and conserving water through adequate crop residue production and management (no-till practices, increasing the cropping intensity, adequate fertilization), SOC has been estimated to have a realistic value of $10 to $20/ton ($5 to $10/acre). To arrive at such benefits, we need an agreed upon methodology for determining verifiable changes in SOC stock (levels). Essentially, we need to know, given laboratory and field spatial variability for SOC and bulk densities measurements: "What are the existing carbon levels and how small a change over time can be measured?" Such changes can be assessed with time for the same treatment (rotation), or in time where different treatments are compared.

APPROACH: To address these questions we conducted research to evaluate differences in SOC concentration at three different laboratories (Akron, Cheyenne, and Lincoln) from: 1) same samples, 2) spatial variability of a common treatment rotation (replicates of the same treatment), and 3) changes from five different rotations (treatment variability) compared to the traditional WW-F rotation, and the existing adjacent native sod.

RESULTS: All three laboratories showed good reproducibility from the same set of samples with CVs less than 5%. Means for the three laboratories were not significantly different. At the Akron lab comparisons were also made comparing the standard C-N procedure with the Walkley-Black and Loss-on-ignition procedures. All three methods showed good correspondence with the C-N analyzer overestimating the calcareous soils. Spatial variability was very significant, but we were still able to obtain SOC treatment differences among the rotations (WF, WCF, WSunF, WCMF, WCSunF,, WCM). Data (corrected for bulk densities) showed that SOC content for WF and WSunF were the same; they were also not different from other rotations with fallow. WCM (no fallow) was the same as rotations with fallow of 3 or 4-year duration. SOC content followed the order: WCM > WCMF>WCF.WCSunF> WSun > WF.

Present methodologies are capable of adequately quantifying SOC stocks, and changes that might occur because of treatment effects. It does appear though, that the treatments may have to be widely different under relatively short time frame (less than 10 years) for significant changes to be detected.

FUTURE PLANS: These results along with others for Akron site spatial variability will be written up for publication.

1. USDA-ARS, Rangeland Resources Research, Fort Collins, CO.
2. USDA-ARS, Soil and water Conservation Research, Lincoln, NE.

MANURE P SORPTION AND RELEASE IN SEMIARID SOILS

R. A. Bowman, M. F. Vigil

PROBLEM: Phosphorus is the second most important soil element for plant growth. Many areas within the Great Plains are deficient in P, so its excess and waste have never been a concern. A serious problem within the Great Plains, though, has always been soil erosion, and secondarily, its association with P. This problem is magnified when eroded P has the potential to enter surface waters and cause eutrofication. This concern, however, is attenuated by the fact that, generally, P loading in our soils is minimal, and consequently, its removal and discharge into surface waters do not present a serious problem. The situation may change, however, with the advent of large containment areas (concentrated animal feeding operations, CAFO), and the need to use and dispose of animal waste and the excess P generated by theses large CAFO units. For this reason many states are developing a **P Index** to facilitate managing P so as not to cause adverse effects on the environment.

APPROACH: A need exists, therefore, to assess the potential of these relatively low-P soils to fix and release organic (Po) and inorganic (Pi) from fertilizers, and P from manures. Our objectives were to assess in acid and calcareous soils: 1) P adsorption isotherms, and consequently, the P buffering capacity, and maximum adsorption with fertilizer and manure P; 2) movement of above P sources in small laboratory columns, and 3) mineralization of manure P in incubation studies. These experiments should help in understanding the mechanisms involved with transportation of P , and fate of P sources in soil and waters.

RESULTS: Chicken and pig manures contained more total P and inorganic P than beef and dairy manures. Manure P was not as available as fertilizer P because of the interaction with Ca and Mg in the manure and other salts. Thus, for manures, adsorption was higher for the same quantity of P because some was fixed or precipitated before P sorption with soils. The CaCO3 eroded soil sorbed the greatest quantity of P, and the sandy loam the least. A wet-dry incubation experiment showed even greater sorption of P than for immediate P addition to soils. The adsorption isotherms are important because equal soil test may not mean the same buffering capacity, and this can only be determined by equilibrating soils with fertilizer P and manure P. It appears that a P buffering capacity (Δ sorbed P on the soil/Δ P concentration in solution) can provide a numerical guide as to when P in solution is increasing, and present an environmental problem.

FUTURE PLANS: There is a need to correlate soil tests with adsorption isotherms, and to evaluate the contribution of organic P in manures to potential movement and ground water problems. The organic P contribution is the area most lacking in data for refinement of the P index. Future research will investigate these areas, along with the role and fate of polyphosphates and phytic acid in the P cycle.

ECONOMICS OF INTENSIVE CROPPING ROTATIONS IN THE CENTRAL GREAT PLAINS

D.A. Kaan, D.M. O'Brien, P.A. Burgener

PROBLEM: Interest has been high among Central Great Plains producers for alternative, intensive, dryland crop rotations compared to traditional wheat-fallow production utilizing conventional tillage practices in the production process. The idea behind these alternative crop rotations is to reduce (or eliminate) the frequency of a fallow period in the crop rotation. Advances in production characteristics for dryland crop varieties and changes in cultural practices have allowed this idea to become reality for many producers in the Central Great Plains region.

APPROACH: Enterprise budgets were developed utilizing best management practices for dryland winter wheat, corn, oil-type sunflowers and proso millet. These budget assumptions were utilized to represent cost of production estimates for each enterprise in an intensive rotation. Market prices for the different commodities were developed utilizing Agricultural Marketing Service price data. Marketing year average prices have been calculated for the corresponding production periods. Yield data in this analysis was obtained from field plot research conducted by Gary Peterson and Dwayne Westfall of Colorado State University. The profitability of a wheat-fallow (W-F) rotation has been compared with a wheat-corn-fallow (W-C-F) rotation over a 1989 to 1997 time period.

RESULTS: Comparing wheat yields in the W-C-F rotation to the W-F rotation shows a two bushel increase in the W-C-F rotation (38 bushel per acre compared to 36 bushel per acre). Corn yields averaged 69 bushel per acre in the W-C-F rotation. The W-C-F rotation produced positive net returns 81 percent of the time and returns greater than $25.00 per acre 56 percent of the time. In comparing the W-C-F and W-F rotations, W-C-F averaged $28.00 per acre net return while W-F averaged $14.00 per acre net return.

FUTURE PLANS: In addition to wheat and corn rotations, oil-type sunflowers and proso millet are common crops utilized in intensive rotations. The authors plan to analyze rotations involving these crops also. Other production and marketing factors such as weather and seasonal price variations will be brought into the analysis to measure these risk factors on profitability.

2000 SUCTION TRAP DATA FOR AKRON, COLORADO

M. Koch

PROBLEM: Monitoring Russian wheat aphid *Diuraphis noxia* (Mordvilko) flight activity gives research and agricultural personnel information towards the potential infestation of crops around the area. The table shows suction trap catches at the Central Great Plains Research Station located four miles east of Akron. Higher than normal precipitation in the summer months of 1999 allowed alternate host plants of the Russian wheat aphid *Diuraphis noxia* (Mordvilko) to flourish. Many of the plants stayed green longer in the fall. This led researchers to believe the aphids would overwinter in abundance and become a major pest to the 2000 wheat crop. This theory did not materialize. It is thought the high temperatures and drought hurt aphid populations.

APPROACH: Collection of aphids is through the use of a suction trap. Traps are 8.3 meters tall and 30.5 centimeters in diameter. They are constructed using the description by Allison and Pike, 1988; Journal of Agricultural Entomology, pages 103-107. Each week samples were collected and the aphids counted. Traps used this past summer were located in Akron, Walsh and Briggsdale, Colorado. The table shows actual aphid catches from the Akron location. The columns are arranged to show catches for the following: RWA, Russian wheat aphid *Diuraphis noxia* (Mordvilko); GB, Greenbug *Schizaphis graminum* (Rondani); BCO, Bird cherry-oat aphid *Rhodalosiphum padi* (Linnaeus); CL, Corn leaf aphid *Rhodalosiphum maidis* (Fitch); EGA, English grain aphid *Sitobion avenae* (Fabricius); RGA, Rose grass aphid *Acyrthosiphon dirhodum* (Walker); NON, non-grain aphids which are primarily Yellow sugarcane aphids *Sipha flava* (Forbes) at the Akron location.

RESULTS: Trap catches for the summer of 2000 were considered average. Infestations in northeast Colorado were light with a few exceptions. Wheat prices along with field conditions below average resulted in small acreages treated for aphid pests. Few aphids were lost to heavy rains which overflowed the collection cup. Note the peak Russian wheat aphid flight in late June. This is common since area wheat fields are drying down and maturing. Aphids must find green food sources to allow them to survive until the fall planted crops emerge.

FUTURE PLANS: The suction trap at the Central Great Plains Research station will continue to be used for aphid flight detection. Currently, there are no plans to shut down this trap site.

Suction Trap catches					Location: Akron (Started 4-17-00)			
Date	**RW A**	**GB**	**BCO**	**CL**	**EGA**	**RGA**	**NON**	**NOTES**
24-Apr	0	3	0	0	0	0	0	
1-May	0	5	0	0	0	0	0	
8-May	0	4	0	0	0	0	2	
15-May	2	0	0	0	0	0	0	
22-May	0	3	0	0	0	0	1	
30-May	16	0	0	0	1	0	1	
5-June	4	0	0	0	0	0	2	
12-June	13	0	0	0	0	0	2	
21-June	41	16	0	0	0	0	0	
29-June	16	15	0	0	0	0	3	overflowed
3-July	11	19	4	0	0	0	5	
10-July	0	7	0	0	0	0	1	
17-July	0	7	8	0	0	5	0	
24-July	3	0	0	1	0	1	0	
31-July	0	0	0	0	0	0	0	
8-Aug	0	0	0	2	0	0	0	
14-Aug	0	0	0	0	0	0	4	
21-Aug	9	0	0	4	0	0	0	
28-Aug	2	0	0	0	0	0	0	overflowed
5-Sept	0	0	0	0	0	0	0	
11-Sept	4	0	5	0	0	0	1	
18-Sept	0	3	1	3	0	0	0	
25-Sept	0	0	0	0	0	0	0	
2-Oct	0	1	0	0	0	0	0	
TOTAL	121	83	18	10	1	6	22	

CONTROL OF SPOTTED SUNFLOWER STEM WEEVIL WITH PLANTING AND CULTIVATION TREATMENTS CENTRAL GREAT PLAINS RESEARCH STATION; AKRON, COLORADO

M. Koch, A. Gebre-Amlak, D. Kennedy, B. Filla

Each plot contained two rows fifty feet long on thirty inch centers. There were twelve plots per replicate arranged in four replicates of a randomized complete block design.

Planting time treatment of Furadan 4F at 1.0 lb Ai/acre was applied on 23 May 2000. The planter was a John Deere Maxi-Merge equipped with a CO_2 powered micro-tube directed into the seed furrow ½ inch above the seed. Cultivation treatments were applied on 10 July 2000 at the V4 to V10 growth stage. A CO_2 powered sprayer with a nozzle (11001 VS-TJ) positioned six inches over the whorl mounted on an Orthman cultivator was used to apply the twelve inch band of insecticide at 17 psi of pressure. At the time of cultivation, Spotted sunflower stem weevil densities were one adult per five plants. Beginning 30 November 2000, five plants per plot were dissected, and sunflower stem weevil larvae in the lower 18 inches of each stalk were counted. Frost conditions forced stalks to be broken off ½ inch below the soil surface. Inspection of the broken roots showed more than 90 percent of the weevil were recovered and counted in the portion above this break. Drought caused a small average stalk diameter of 2.1 centimeters and an average height of 118 centimeters.

Counts were subjected to analysis of variance and mean separation by the Student-Newman-Keuls method.

When compared to the untreated check most treatments reduced stem weevil larvae counts. Furadan 4F at 1.0 lb. Ai/acre applied during planting or at cultivation had fewer stem weevil than all other treatments (Table 1). No phytotoxicity was observed throughout the growing season.

Field History:

Pest:	Spotted sunflower stem weevil, *Cylindrocopturus adspersus* (LeConte)
Cultivar:	Cargill SF187 oil seed
Planting Date:	23 May 2000
Plant Population:	18,000
Irrigation:	None
Crop History:	Corn previous year
Herbicide:	Sonalan 10G at 13.5 lbs. per acre
Insecticide:	None prior to experiment
Fertilization:	Nitrogen at 20 lbs. per acre
Soil Type:	Weld Silt Loam and Platner Loam, OM 1%, pH 7.0
Location:	USDA Central Great Plains Research Station, Akron, CO.

Table 1. Control of spotted sunflower stem weevil with planting and cultivation timed treatments, Central Great Plains Research Station, Akron, CO 1999

Treatment, lb AI/acre		Timing	SSW [1] Larvae/Plant	% Control	% Lodging
Untreated		---	14.85 A	---	53
Asana XL 0.66E	0.03	Cultivation	14.80 A	20	56
Asana XL 0.66E	0.05	Cultivation	12.85 B	30	54
Baythroid 2E	0.03	Cultivation	7.05 C	62	14
Baythroid 2E	0.02	Cultivation	6.40 C	65	6
Mustang 1.5E	0.045	Cultivation	6.35 C	66	12
Furadan 4F	0.75	Cultivation	5.80 C	69	8
Warrior 1E	0.03	Cultivation	5.80 C	69	9
Warrior 1E,	0.02	Cultivation	5.45 C	70	11
Mustang 1.5E	0.03	Cultivation	5.00 C	73	8
Furadan 4F,	1.0	Cultivation	1.55 D	92	11
Furadan 4F,	1.0	At-Planting	1.30 D	93	7
F value			88.91		
p>F			0.0001		

[1] Means in the same column followed by the same letter(s) are not statistically different, SNK (¥=0.05).

EFFECTS OF CROPPING ROTATIONS ON BENEFICIAL AND PEST INSECTS AT THE CENTRAL GREAT PLAINS RESEARCH STATION; AKRON, COLORADO

M. Koch

PROBLEM: In 1986 the Russian wheat aphid (RWA) became a major small grains pest in Colorado. Control methods for this pest include cultural, mechanical, chemical, and biological. Russian wheat aphid control has been most effective using chemicals. However, producers may be able to combine cultural and biological techniques to decrease the need for other costly control measures. This would also diversify production on a given farm. Crops grown in close proximity to one another providing a year-long host of green vegetation may allow predators and parasites to survive and control pests. To test this theory, plots were established at three locations in eastern Colorado. Plot size was determined by the area available at each location.

APPROACH: This site was established in the spring of 1996. The previous crop was corn with a small area used for sunflowers. Crop rotations were selected for research based on area production practices. The rotations used are as follows: winter wheat-fallow; winter wheat-corn-fallow; winter wheat-corn-millet; and winter wheat-corn-sunflower-fallow. The individual plots are large at 90 feet wide by 180 feet in length. Experimental layout was in a complete randomized block with four replications. Each phase of the rotations were present every year in each replicate. Each of the wheat plots are divided in half lengthwise. One half was a susceptible variety and the other a resistant variety to the Russian wheat aphid *Diuraphis noxia* (Mordvilko). The varieties used for the 2000 wheat crop were TAM 107 as the susceptible and Prairie Red as the resistant.

Wheat was planted on 06 September 1999 with a John Deere 750 no-till drill. Planting rate was 60 pounds per acre. Fertilizer was applied at planting in a band two inches above and to the side of the seed. Fertilizer rates were 60 pounds of nitrogen and 15 pounds of phosphorus. Formulations were liquid 10-34-0 and 32-0-0, which were banded using separate tubes. No-till plots were treated with Roundup Ultra *Glyphosate* prior to planting. No other herbicides were used during the growing season.

Corn was planted on 16 May 2000 using a John Deere max-emerge planter. The planter was six rows wide and delivered 16,600 seeds per acre on 30 inches of spacing between rows. The variety used was Asgrow RX 489RR. Fertilizer was applied at planting using 98 pounds of nitrogen, 20 pounds of phosphorus and 1.5 pounds of zinc per acre. Formulations were liquid 32-0-0, dry 0-46-0 and 10-0-0-10 ammoniated zinc. Zinc was mixed with the liquid nitrogen and banded two inches above and to the side of the seed. Dry phosphorus was applied through a drop tube placed with the seed. A Roundup Ready corn variety was selected due to a Field sandbur *Cenchrus incertus* problem in the plot area prior to the establishment of this study. An application of Roundup Ultra RT *Glyphosate* at one quart per acre was used on 12 May to clean up the plots prior to planting. Lack of precipitation made this application of herbicide the only necessary treatment to keep the plots weed free.

Sunup proso millet was planted on 08 June 2000 using a John Deere 750 no-till drill with a 7.5 inch row spacing. Thirty-five pounds of nitrogen and 15 pounds of phosphorus were applied at planting. The liquid 32-0-0 and dry 0-46-0 were applied in the seed furrow with 15 pounds per acre of seed. A single application of one quart of Roundup Ultra RT on 12 May cleaned up the plots.

Sunflowers were planted on 08 June 2000 using a six-row John Deere max-emerge planter. Row spacing was 30 inches and Triumph 545 was the variety used. Fertility was enhanced with 42 pounds of nitrogen and 15 pounds of phosphorus. The liquid fertilizers used were 32-0-0 and 10-34-0 banded two inches above and two inches to the side of the seed. A single application of Sonalan 10G

Ethalfluralin at 16 pounds per acre was applied on 29 May. Mechanical incorporation of the herbicide was accomplished with a sweep plow using 18 inch sweep points. Hot and dry weather conditions as well as the tilling of the soil caused planting conditions to be very dry. Lack of emergence resulted in abandonment. A filler crop of soybeans was planted 15 August to use moisture from the soil profile. Several varieties of soybeans were mixed in the seed box of a John Deere 750 no-till drill. Row spacing was 7.5 inches.

All fallow plots were treated as no-till except the winter wheat-fallow rotation which was conventionally tilled. Roundup *Glyphosate* was used to control weeds in the no-till plots when needed. Only three applications were necessary due to the drought. The applications were made on 18 April, 01 August and 10 October. Each application of Roundup was made with a Tyler Patriot sprayer at 10 gallons of mix per acre. The conventionally tilled plots were tandem disked on 27 April and sweep plowed with treaders on 23 June and 25 August.

Data collected for each rotation and crop includes the following: soil moisture, residues, grain versus straw ratios, insects, weeds, and yields. For the purpose of this report insects, weeds and yields will be included in the results.

RESULTS AND DISCUSSION: Yields were below average for all crops this year. Soil surface moisture was good at wheat planting. Precipitation during the remainder of the year was low except for the month of March 2000 (Table 1). This month recorded 2.33 inches of precipitation compared to an average of 0.81 inches. Fall planted wheat began spring regrowth and tillering early and looked good. Then the drought forced the plants to abort tillers and wheat yields were reduced. Plot harvesting was done on 02 July using a Wintersteiger Elite small plot combine with an all-crops head. Plots averaged 25.42 bushels per acre. Prairie Red edged TAM 107 with an average of 25.83 compared to 25.01 bushels per acre. The wheat-fallow rotation yielded highest with an average of 28.09 bushels per acre. Wheat-corn-fallow and wheat-corn-sunflower-fallow rotations were similar in yield with averages of 27.89 and 27.04 bushels per acre respectively. The wheat-corn-millet rotation was the loser on this dry year with an average of 18.68 bushels per acre. See Table 2 for yield comparisons.

Wheat pests were present in low numbers throughout the entire growing season. Mites and aphids were the prevalent insect pests. Neither accounted for economic damage. Russian wheat aphids per 100 random tillers did not exceed eight when put in Berlese funnels for 24 hours. No cutworms were found at this location. Bird-cherry oat aphids *Rhopalosiphum padi* Linn, Greenbugs *Schizaphis graminum* Rond and Onion thrips *Thrips tabaci* Linderman were found in low numbers throughout the growing season. They did not become an economic threat. Ladybird beetles were the primary predators in the wheat while a few spiders were also observed.

Corn plots were poor with an overall average of 19.44 bushels per acre. Harvesting was done on 13 October using a John Deere 9400 combine with an all-crops head. The wheat-corn-fallow rotation yielded the most with an average of 23.79 bushels per acre. The other rotations of wheat-corn-millet and wheat-corn-sunflower-fallow had yields of 22.19 and 12.35 respectively. Hail on 21 July damaged all of the plots as they were beginning the tasseling stage. Severe damage to the wheat-corn-sunflower-fallow plot in replicate four brought the yield average down for this rotation. The yield for this rotation, without including replicate four, averaged 14.76 bushels per acre. A comparison of the corn yields can be seen in Table 3 at the back of this report.

Insect pests in the corn were not of economic importance. There were no cutworms found this year. Aphid species present were Greenbugs *Schizaphis graminum* Rond, Bird-cherry oat aphids *Rhopalosiphum padi* Linn, and Corn leaf aphids *Rhopalosiphum maidis*. None of these were found at any of the crop development stages. Onion thrips *Thrips tabaci* Linderman were also noted but did not pose a threat to plant health.

Millet yields were established using the 9400 John Deere combine with a pick-up head after the plots had been swathed and allowed to dry. Average yield for all four plots was 12.91 bushels per acre. The low yield was again caused by the lack of moisture available. Very little pest pressure was observed throughout the growing season. Onion thrips *Thrips tabaci* Linderman, were present all season. However, no damage was seen on the plants. Greenbugs *Schizaphis graminum R*ond and Bird-cherry oat aphids *Rhopalosiphum padi* Linn were also noted. The number of aphids was well below economic thresholds. Spiders were the main predators seen in the plots. Also, Ladybird beetles were present to help control the pests.
Sunflower stand counts were very poor from lack of moisture. Tilling of the soil to incorporate the herbicide dried the planting zone. Therefore, germination was not possible. It was determined in July to abandon the sunflowers and plant soybeans as soon as there was enough moisture to get a stand. The soybeans were planted 15 August after receiving a half inch of rain the first week of this month. Stands were excellent and used enough moisture to be of value. No entomological data was collected from the plots.

FUTURE PLANS: The cropping rotation study will continue for the coming year with no changes to experimental layout. Varieties and planting rates may change as well as certain sampling techniques.

Table 1. Precipitation data for the Central Great Plains Research Station, 2000.

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
2000	0.23	0.33	2.33	1.09	0.75	0.76	2.69	2.11	1.58	1.91
92 Yr. Average	0.34	0.37	0.81	1.66	2.98	2.45	2.69	2.10	1.20	0.91
Difference	-0.11	-0.15	1.37	0.80	-1.43	-3.12	-3.12	-3.11	-2.73	-1.73

Table 2. Wheat yields for the cropping rotation study at Akron, CO 2000

PLOT	VARIETY	ROTATION	TOTAL WT	% MOISTURE	TEST WT	YIELD	ADJ YLD 12.5%
102	TAM 107	W-C-M	9217.6	8.8	57.6	15.6	16.3
	P. RED		9492.8	8.8	57.7	16.1	16.8
103	TAM 107	W-C-F	9888.6	8.1	55.5	28.4	29.9
	P. RED		10004.4	8.2	56.0	27.1	28.4
110	TAM 107	W-F	9126.0	8.2	55.6	24.7	25.9
	P. RED		9747.2	8.4	56.9	26.2	27.4
112	TAM 107	W-C-S-F	10571.6	8.3	55.8	30.1	31.5
	P. RED		9544.4	8.0	54.9	28.0	29.4
203	TAM 107	W-C-M	9101.4	8.8	57.3	14.9	15.5
	P. RED		10204.8	8.9	58.9	16.8	17.5
205	TAM 107	W-C-F	9166.6	8.4	56.8	23.3	24.4
	P. RED		9430.4	8.4	56.8	24.0	25.1
206	TAM 107	W-F	7795.8	8.4	56.2	22.6	23.7
	P. RED		8816.0	8.1	56.1	25.3	26.6
207	TAM 107	W-C-S-F	9043.6	8.0	54.8	22.2	23.3
	P. RED		9642.2	8.0	54.7	23.7	24.9
308	TAM 107	W-C-M	9547.8	8.7	58.7	21.7	22.7
	P. RED		8794.5	8.7	58.3	20.3	21.2
309	TAM 107	W-C-F	8373.8	8.5	58.5	24.6	25.7
	P. RED		9040.2	8.5	58.3	26.5	27.7
310	TAM 107	W-C-S-F	10393.6	8.1	55.6	29.6	31.1
	P. RED		10351.6	7.8	54.9	30.1	31.7
311	TAM 107	W-F	10587.7	8.2	56.4	30.7	32.3
	P. RED		10587.6	8.3	56.8	30.7	32.2
402	TAM 107	W-F	8893.0	8.1	54.4	25.1	26.3
	P. RED		9865.8	8.3	55.4	28.9	30.3
407	TAM 107	W-C-S-F	8694.2	7.9	55.1	19.5	20.5
	P. RED		10596.8	7.9	55.0	22.7	23.9
409	TAM 107	W-C-M	11331.0	8.7	59.6	19.2	20.0
	P. RED		11114.2	8.9	59.9	18.6	19.4
412	TAM 107	W-C-F	8443.2	8.0	56.0	29.5	31.1
	P. RED		7947.6	8.1	55.2	29.4	30.8

AVG 25.4 BU/A

Table 3. Corn yields for the cropping rotation study at Akron, CO 2000.

Plot	rotation	weight	moisture	test wt.	yield	adj. yield
106	w-c-f	341	11.4	53.0	16.37	20.70
107	w-c-s-f	340	11.3	53.4	16.32	20.74
111	w-c-m	263	11.3	52.8	12.62	16.05
204	w-c-f	405	11.5	53.1	19.44	24.46
208	w-c-m	231	11.1	52.6	11.09	14.24
211	w-c-s-f	170	11.6	53.5	8.16	10.21
301	w-c-m	143	11.7	52.5	6.86	8.55
302	w-c-s-f	223	11.7	53.2	10.70	13.33
307	w-c-f	337	11.9	53.3	16.18	19.93
401	w-c-s-f	86	11.8	53.0	4.13	5.11
403	w-c-m	814	11.2	53.7	39.07	49.91
410	w-c-f	508	11.9	54.3	24.39	30.05

FORAGE AND SEED YIELD OF SEVERAL PEA AND SOYBEAN VARIETIES

D.C. Nielsen

PROBLEM: Diversifying dryland production systems in the central Great Plains requires knowledge regarding the productivity of alternative crops. Producers have shown interest in both forage and seed production of soybean and pea, yet seed yield and forage yield and quality information is not available.

APPROACH: One Pioneer (P) and 4 Asgrow (A) standard seed soybean varieties (maturity groups 2.9 to 4.3), and one pea variety (Arvika) were evaluated for seed yield and forage yield and quality. Seven other pea varieties were evaluated for seed yield. One commercial (Donegal) and four experimental forage soybean varieties were evaluated for forage yield and quality. Planting dates and rates and harvest dates are given in the table below. Seeding was done with a JD 750 drill with 15 in. row spacing.

RESULTS: Below normal precipitation resulted in much lower forage and seed yields than in 1999. Forage quality was good for all varieties tested. The experimental forage soybean lines showed good production potential under these dry conditions. The forage soybean lines did not reach physiological seed maturity. Forage quality analyses are still being conducted. Lowest soybean pods were 2.0 in. higher wheat stubble than in clean till seed bed preparation.

	Planting Date	Forage Harvest Date	Seed Harvest Date	Forage Growing Season Precip	Seed Growing Season Precip	Planting Rate	Final Plant Stand	Forage Dry Weight	Moisture at Forage Harvest	Crude Protein	NDF	ADF	TDN	RFV	Seed Yield
Soybean				(in)	(in)	(seed/a)	(pl/a)	(lb/a)	(%)	(%)	(%)	(%)	(%)		(bu/a)
P 9294	15 May	18 Aug	10 Oct	4.87	8.75	165000	162900	1826	72	11.7	35.8	29.1	67.6	172	7.0
A 3302	15 May	29 Aug	10 Oct	6.02	8.75	165000	145200	1687	70	12.6	37.4	30.6	66.0	162	8.0
A 3701	15 May	22 Aug	10 Oct	4.92	8.75	165000	155800	1794	70	16.0	36.3	28.1	68.6	172	9.3
A 3901	15 May	18 Aug	10 Oct	4.87	8.75	165000	106200	1815	71	13.0	35.8	29.4	67.2	171	10.3
A 4301	15 May	29 Aug	10 Oct	6.02	8.75	165000	145200	1887	71	13.6	35.2	30.2	66.4	173	8.3
Donegal	15 May	18 Sep		6.14	8.75	200000		2627	63						
PL88-1	15 May	18-Sep		6.14	8.75	200000		3522	66						
PS1-BL37	15 May	18 Sep		6.14	8.75	200000		3649	65						
97VA-18	15 May	22 Sep		7.30	8.75	200000		5866	71						
OH-49	15 May	22 Sep		7.30	8.75	200000		5078	71						
Pea						(lb/a)									(lb/a)
Arvika	10 Apr	20 Jun	14 Jul	2.41	3.15	128	368200	2415	68	19.7	34.7	26.0	70.8	184	410
Profi	10 Apr		14 Jul		3.15	180	240800								1233
Alfetta	12 Apr		14 Jul		3.15	180	198300								1120
Majoret	12 Apr		14 Jul		3.15	180	283200								1007
Integra	12 Apr		14 Jul		3.15	180	205400								805
Atomic	12 Apr		14 Jul		3.15	180	184100								1593
Carneval	12 Apr		14 Jul		3.15	180	177000								1310
Toledo	12 Apr		14 Jul		3.15	180	198300								970

FUTURE PLANS: More extensive testing of the true forage soybean varieties will begin in 2001, including irrigation gradient studies to determine water use/yield response. Other seed variety soybeans will be tested as we look for varieties that will resist spontaneous pod opening under the dry fall conditions of the central Great Plains.

CROP ROTATION AND TILLAGE EFFECTS ON WATER USE AND YIELD OF ALTERNATIVE CROP ROTATIONS FOR THE CENTRAL GREAT PLAINS

D.C. Nielsen, R.L. Anderson, R.M. Aiken, M.F. Vigil, R.A. Bowman, J. Benjamin

PROBLEM: Increased use of conservation tillage practices has made more soil moisture available for crop production in the central Great Plains, thereby providing greater opportunities for more intensive crop production as compared with conventional wheat-fallow. Information is needed regarding water use patterns, rooting depth, water use/yield relationships, precipitation storage and use efficiencies, and water stress effects of crops grown in proposed alternative rotations for the central Great Plains.

APPROACH: Six rotations [W-F(CT), W-C-F(NT), W-C-PEA(RT), W-SUN-F(RT), W-M-SUN-F(RT), W-SUN-M-PEA(RT)] are used for intensive measurements of water use and water stress effects on yield. (W:winter wheat, C:corn, F:fallow, M:proso millet, SUN:sunflower, PEA:pea CT:conventional till, RT:reduced till). Measurements include soil water content, plant height, leaf area index, grain yield, residue mass and cover, and precipitation.

RESULTS:

Rotation	Crop	ET (in)	Yield (lb/a)
W-F(CT)	wheat	10.2	1456
W-C-F(NT)	wheat	11.1	1964
W-C-PEA(RT)	wheat	7.5	1068
W-SUN-F(RT)	wheat	9.9	1369
W-M-SUN-F(RT)	wheat	8.9	1407
W-SUN-M-PEA(RT)	wheat	6.0	496
W-SUN-M-PEA(RT)	pea	4.3	411
W-C-PEA(RT)	pea	3.8	241

Rotation	Crop	ET (in)	Yield (lb/a)
W-C-PEA(RT)	corn	11.3	447
W-C-F(NT)	corn	12.0	532
W-SUN-F(RT)	sunflower	8.8	516
W-M-SUN-F(RT)	sunflower	8.2	481
W-SUN-M-PEA(RT)	sunflower	10.5	805
W-M-SUN-F(RT)	millet	8.3	986
W-SUN-M-PEA(RT)	millet	6.7	80

INTERPRETATION: Very dry conditions (less than 30% of normal precipitation) for May, and June reduced wheat and pea yields. The most severe wheat yield reduction was in the continuously cropped W-SUN-M-PEA rotation. Corn yields were very low due to the low May and June precipitation which restricted vegetative development combined with only 2.75 in. of precipitation during the critical 15 Jul-25 Aug period. As in the past 3 years, wheat yields were higher (about 20%) than expected for the measured amount of water use. This coincides with our switch in varieties from 'TAM 107' to 'Akron', but a yield advantage of 'Akron' over 'TAM 107' has not been seen in the Colorado State University variety trials conducted at this location the past 3 years.

FUTURE PLANS: Water use, yield, rooting depth, height, leaf area, and growth stage measurements will continue to be made for as long as these rotations exist. An analysis of fallow season precipitation storage efficiency by residue type, rotation, and time of precipitation will be written for journal publication this year.

WATER USE, YIELD AND AGRONOMIC PRODUCTION OF ALTERNATIVE CROPS UNDER AN IRRIGATION GRADIENT

D. C. Nielsen

PROBLEM: Increased use of conservation tillage in the central Great Plains has increased precipitation storage efficiency and made more soil moisture available for crop production, thereby providing greater opportunities for more intensive crop production as compared with conventional wheat-fallow. Future successful and profitable agricultural production will likely be improved with increased diversity of production. Adding new crops to the traditional crops grown in this area will increase diversity. There are many unknowns associated with diversifying agricultural production with alternative crops, such as water requirements, water use-yield functions, rooting patterns, and water stress effects on plant growth, development, and yield.

APPROACH: The plot area was under a solid set, gradient irrigation system. Plots were arranged such that there would be 4 replications of 4 levels of irrigation, with the highest irrigation level being weekly replacement of water used and the lowest level being rainfed with no supplemental irrigation. Soil water measurements were made with a neutron probe. Water use (ET, evapotranspiration) was computed by the water balance method.

Crop	Variety	Planting Date	Harvest Dates
Field Pea	Profi	10 Apr	29 Jun
Forage Pea	Arvika	10 Apr	3,7,11,24 Jul
Chickpea	Myles	12 Apr	13,19,24 Jul
Soybean	Pioneer 9294	15 May	22,23,25 Aug; 18,27,29 Sep
Forage Soybean	Donegal	8 Jun	18,22 Sep
Cowpea	Peregrin	8 Jun	6,8,11,12 Sep

RESULTS:

Crop	Gradient Position	Forage ET (in)	Seed ET (in)	Dry Forage Yield (lb/a)	Seed Yield (lb/a)	Forage Crude Protein (%)	Relative Feed Value
Field Pea	1 (dry)	---	7.3	---	1742	---	----
(Profi)	2	---	10.1	---	2480	---	---
	3	---	12.7	---	3003	---	---
	4 (wet)	---	19.6	---	3670	---	---
Forage Pea	1 (dry)	7.3	9.8	3643	969	20.5	181
(Arvika)	2	9.9	12.7	3352	2171	18.3	182
	3	12.0	15.6	5211	1742	22.4	154
	4 (wet)	12.9	19.4	4360	2099	24.2	151
Soybean	1 (dry)	11.1	13.6	2933		17.7	163
(Pioneer)	2	11.8	15.4	3015		13.4	156
	3	14.6	19.5	3296		13.0	155
	4 (wet)	18.4	23.6	3874		12.4	154

Crop	Gradient Position	Seed ET (in)	Dry Forage Yield (lb/a)	Seed Yield (lb/a)
Forage Soybean	1 (dry)	---	2627	---
(Donegal)	2	---	---	---
	3	---	12811	---
	4 (wet)	---	---	---
Chickpea	1 (dry)	8.3	---	1219
(Myles)	2	11.4	---	1660
	3	15.4	---	1803
	4 (wet)	19.3	---	1566
Cowpea	1 (dry)	10.5	---	882
(Peregrin)	2	12.0	---	1162
	3	15.5	---	1447
	4 (wet)	20.2	---	1428

INTERPRETATION: All crops showed yield increases with increased water use. Some responses (Profi pea seed, Pioneer soybean forage) were stronger than others. The Donegal forage soybean appears to be more promising for forage production than the standard soybean variety.

FUTURE PLANS: Dry bean results (from previous years) will be submitted for publication. Work will continue with Arvika pea, soybean (forage), cowpea, and chickpea. More detailed work with the true forage soybean types will begin as we obtain seed from ARS breeder, Dr. Tom Devine, Beltsville, MD.

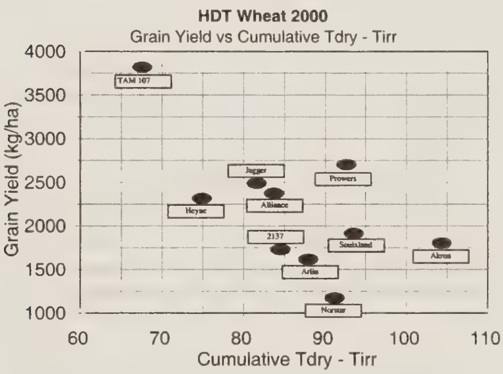
WINTER WHEAT VARIETAL YIELD DIFFERENCES RELATED TO CANOPY TEMPERATURE DIFFERENCES

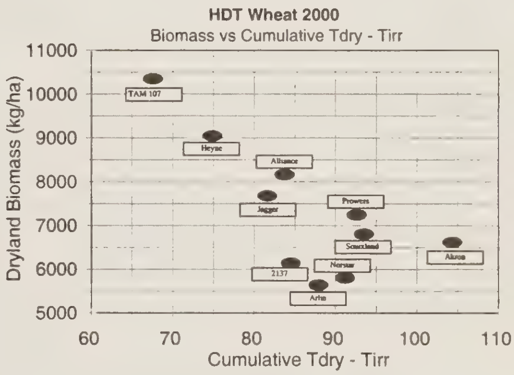
David C. Nielsen

PROBLEM: Drought stress regularly limits winter wheat yield in the central Great Plains. I hypothesize that varieties that are better able to maintain their non-water-stressed canopy temperatures under water stress will yield higher under water stress than varieties which do not maintain their non-water-stressed canopy temperature under water stress. Monitoring of stressed and non-stressed canopy temperatures will therefore be a quick screening tool to identify varieties adapted to drought stress.

APPROACH: Ten varieties of winter wheat (TAM107, Jagger, Arlin, Prowers, Siouxland, Akron, Alliance, Norstar, 2137, Heyne) were grown in small plots (15' by 40') under two water treatments (rainfed and full irrigation), replicated twice. Canopy temperatures were monitored daily with an infrared thermometer between 1300 and 1400 MDT. Cumulative difference between canopy temperatures of rainfed and fully irrigated plots was compared to dryland grain yield and biomass for each of the ten varieties.

RESULTS:





INTERPRETATION: Higher values of Cumulative Tdry-Tirr indicate higher levels of water stress. Both biomass and grain yield of the dryland treatment declined with increasing water stress. TAM107 showed the least amount of water stress, and the highest yield. Akron, Siouxland, and Norstar had higher levels of water stress and lower yields and biomass. Prowers also had a higher level of water stress but with an intermediate yield and biomass. It appears that canopy temperatures under water stressed and non-stressed conditions can yield useful information relative to a variety's yielding ability under water stress.

FUTURE PLANS: The experiment will be repeated next year, with the addition of varieties Halt and Yumar. Results will be compared with results from a similar experiment being conducted on the same varieties in Ft. Collins by Greg McMaster.

INSECTS IN DRYLAND CROPPING SYSTEMS AT BRIGGSDALE

D. J. Poss

PROBLEM: The Russian wheat aphid (RWA) has become a major pest in small grains in Colorado. Cultural, mechanical, chemical, and biological control methods are all possible. Chemical control has been the most effective however it is costly and is not a long term solution. Combining cultural and biological controls may be the best choice. Biological control may be more effective in a more diverse cropping system since predators can survive off of insects in other crop when wheat is no growing.

APPROACH: The plots are 3 miles south of Briggsdale. 1999 was the first season at the Briggsdale site. Prior to 1999, the cropping system at this site was wheat/millet/fallow (WMF). The plots are 90 ft. wide by 410 ft long. The plots are large compared to most conventional experiments to allow us to study insects. The rotations at this site include two that represent typical rotations for the area (Wheat/Fallow and Wheat/Millet/Fallow), a longer rotation that allows us to experiment with nontraditional crops (Wheat/Wheat/Corn/Soybean/Sunflower/Pea) and an opportunity cropping where we crop it as much as possible to maximize biomass production. Two wheat varieties are planted in each plot, one which is susceptible to the Russian wheat aphid (RWA) and one which is not.

Insects are counted and collected at the critical growth stages for each crop (3 to 4 stages per crop). We are interested in the effect rotations have on both pest and beneficial insects

Data collected in 2000 included yields for all crops, soil N before planting each crop, residues at planting, and pest and beneficial insect populations in all crops.

RESULTS: The precipitation received at Briggsdale in 2000 was below normal. For the period May through September precipitation was less than 50% of normal resulting in low yields of all of the summer crops. A freeze on 13 May resulted in many wheat heads turning white and many sterile spikelets in other heads.

Wheat yields averaged 14.6 bu/ac over all rotations with the wheat in the WF rotation yielding significantly more than either wheat crop in the continuous WWCSbSfP rotation. The yields between the varieties were not significantly different. Corn yields were low averaging 11.0 bu/ac. The drought played a significant roll in these low yields, however raccoons caused nearly 100% damage in one of the plots and a significant amount of damage in another plot out of four plots. Sunflowers averaged 456 lb/ac., also a very low yield. Millet was not planted due to the drought and dry soil conditions at planting. Soybeans were planted, however rabbits destroyed three out of eight plots and caused significant damage on the other plots so yields were not taken.

Insects in wheat were present however populations were not high enough to cause economic damage. Russian wheat aphid (RWA), other cereal aphids and brown wheat mites were present in relatively low populations. There were statistically more RWA's in the WMF rotation than the first wheat in the WWCSbSfP rotation. For brown wheat mite there were less mites in the first wheat of the WWCSbSfP rotation than the other rotation due to the later planting date and thus less tillering. Coccinellids (ie. lady beetles) were the primary predators found in wheat. Insect populations for all other crops were low due to the drought.

FUTURE PLANS: This is a long term experiment expected to last a minimum of ten years.

LEGUME N CREDITS IN WINTER WHEAT LEGUME ROTATIONS

M. F. Vigil, D. C. Nielsen, R. A. Bowman.

PROBLEM: With the exception of water, nitrogen (N) nutrition is the most important limiting input to profitable winter wheat production in the central Great Plains. Increases in N fertilizer costs have caused some farmers to consider alternative systems that include legumes as a source of N. Farmers need to know how these systems impact winter wheat yields, economic returns and N availability. The two sites previously established in which the main plots consist of legume species: Austrian winter peas, spring field pea (cv. Profi), Hairy Vetch and a no-legume-summer-fallow plot fertilized at four N rates 0, 30, 60, and 90 lb N/ac are now being used for a two year follow up study. The objectives of the follow up experiment are (1) to determine the fertilizer N response of wheat following the legumes, (2) to determine the N response of the legumes and (3) to determine the difference in N response of the legume wheat rotation as compared to wheat fallow.

APPROACH: Legumes are planted early in April or late March. Weeds growing in the fallow plot are allowed to grow and use water until the legumes are terminated. Legumes and weeds in summer fallow are terminated at the same time, usually the first or 2nd week of June. Before planting wheat in legume stubble each fall, the legume plots are divided into 4 subplots and each subplot is fertilized with either 0, 30, 60, and 90 lb N/ac. Soil inorganic N is measured in each plot, at each termination date, in the top 3 feet of soil, and at wheat planting time to monitor changes in available N. Just after fertilizing legume stubble, wheat is planted. Grain yield is measured using standard BMP's for dryland winter wheat. Equations are fitted to the wheat-grain-yield-response to added N fertilizer for the legume-wheat plots and the wheat-fallow plots. If there is a legume N credit the N response curve for wheat following the legume plots should be higher on the vertical axis than the fallow N response curve. This is assuming that the weeds use the same amount of water as the legumes.

RESULTS: No results yet for this new follow up experiment. In the earlier experiment Austrian Winter peas (AWP) produced more biomass (between 1500-3000 lbs biomass/acre) and total above ground N in plant tissue (50-130lbs N/acre) than the other legumes tested. Profi pea has averaged 1000-1500 lbs of grain per acre and has had the highest grain yields. For the AWP we calculated a water-use efficiency of 335 lbs of dry matter per inch of water used on June 13, 1994. The 335 lbs of biomass, contained 11.6 lb of N. In other words, 11.6 lbs of N was fixed or taken up by the legume for each inch of water use. We measured reductions in wheat grain yields all four years. Generally the highest yield reductions were with the later termination dates. Sometimes the earliest termination dates did not result in a significant reduction in grain yield. Eighty-eight % of the variability in wheat yield loss could be described by a equation based on the previous year's legume water use (ET). Legume green fallow increases wheat-grain-N contents similar to fertilized summer fallow. However, the increase does not increase wheat yield and or cause a large increase in grain-N-uptake when compared to traditional summer fallow.

FUTURE PLANS: We will conduct the follow up experiment for two years. Three publications have resulted from the study.

IN FIELD MEASUREMENT OF N MINERALIZATION FROM ANIMAL MANURE

M. F. Vigil, B. Jacubowski, J. Davis, B. Eghbal, R. A. Bowman

PROBLEM: The disposal of animal waste and municipal sewage sludge from large population centers and concentrated animal feeding units is an environmental concern. These materials, loaded with organic and inorganic nutrients, can be recycled in crop production systems as fertilizer and soil quality amendments. If managed properly, they become a resource instead of waste. However, the quantification of suitable rates of application, methods of application, crop response, and changes in soils after repeated application are data needed to adequately develop best management practices (BMP's) for these amendments.

APPROACH: The objectives of these experiments are to determine: (i) the amount and rate of decomposition of organic amendments (manures and sewage sludge) in farm soils, as fertilizer and as soil quality amendments for crop production. The field in-situ/ion-resin core method is being used to estimate field N mineralization (N_{min}) of 5 different manures in a Weld silt loam. Lab studies are being conducted on 20 select animal manures representing 7 animal species. N_{min} and C_{min} are being measured in manure amended Central Great Plains soils to develop first-order-decay-rate constants for these materials. Simultaneously we are evaluating computer models for their ability to predict how these amendments will impact soil nutrient availability and crop uptake. Field studies with the resin-bag In-situ N_{min} method are complete.

RESULTS: We have analyzed the measured N_{min} at three weeks after application for the in-situ field N_{min} study. As much as 14% of the total N applied in hog-manure was recovered 3 weeks after application using the resin-core method, and only 3.3% for beef-manure. After 45-weeks, we measured 14% of the beef-manure and 19% of the N applied as hog-manure was mineralized under irrigated conditions. Under dryland conditions we measured 23% of manure-N applied the previous November had mineralized by June the following year. This data indicates that less than 30% of the N applied as animal manure will be available for crop production within one year after application. This means that up to 70% of the manure-N applied can't be counted on for crop production in the first year. We estimate from our lab studies that dry-granulated sewage sludge (5.3% N) applied at rates of 1.5 ton and 9 ton per acre will release 45 and 270 lbs of N in a given season under irrigated conditions in our region (about 28% of the total N applied). This analysis suggests that if a dryland corn crop needed 80 lbs N/acre (as determined by soil test) and the farmer had a manure with 3% N on an dry weight basis, we might expect that the manure would release 25% of the manure-N during maximum crop uptake (V6 to tasseling). This would require 11,000 lbs of manure/acre (dry weight basis) to satisfy the corns N requirement. Because manures are not completely dry the actual amount added would be more than 11,000 lbs/acre. For example, if the manures was 30% water by weight then 15,714 lbs or 8 ton would be required to get 80 lbs of N available in one season.

FUTURE PLANS: Lab studies are mostly complete and data is being analyzed. The In-situ N_{min} field studies are mostly complete. We hope to finalize the lab studies by end of summer 2001. The in-situ N_{min} study will be finalized by December 2000.

ROUNDUP-READY SOYBEANS THE SEVENTEENTH CROP OF A DRYLAND ROTATION WITHOUT SUMMER FALLOW

M. F. Vigil, R. A. Bowman, A. Halvorson

PROBLEM: Conservation tillage has increased annual soil water storage. This enables the use of annual cropping for some soils of the central Great Plains. Annual cropping entails greater biomass production which increases surface crop residues impacting soil quality and soil water storage. This study was designed to evaluate long term changes in soil C and N under annually cropped dryland conditions under different N fertility. Short term, the study allows for the estimation of N use efficiency and fertilizer N requirements of various dryland crops.

APPROACH: This is the 17th year of the experiment (started by Ardel Halvorson in 1983), where under dryland conditions, the site is cropped continuously with no summer-fallow on a Weld silt loam. The site was a barley-corn rotation until 1992 when oats for hay replaced barley. We have had 14 successful years and three failures in the 17 years of cropping: winter wheat was grown in 1988 to replace a hailed out corn crop in 1987; in 1990, poor stand and aphids limited barley yields to 21 bu/acre; and in 2000, Round-up-ready-soybeans (category 3) made between 8 and 13 bushel. The experiment is a 4-rep RCB where the only treatment is N fertilizer rates of 0, 20, 40, 60, 80 or 120 lbN/acre. The study is managed with no-till to conserve water, and weed control has been through the use of contact and residual herbicides. Phosphorous (P) nutrition has not been limiting but low rates of P have been applied with the seed at planting or as broadcast treatments. Soil profile water and nitrates are monitored annually to determine N balance and water use efficiency.

RESULTS: Through the years, the optimum N rate for the grain crops has been between 40 and 60 lbs N/acre for wheat and between 60 and 80 lbs for corn. A buildup of excess nitrate-N can be found in the soil of plots fertilized at 80 lbs or more. These results suggest that with this soil (under dryland conditions) annual fertilizer N rates greater than 80lb/acre, are excessive for the crops and management currently available. Triticale yields in 1995 were 5.5 ton/acre at an optimal N rate of 80 lb/acre. In 1996, maximum corn grain yields of 90 bu/acre were measured at the 120 lb N rate. At the 80 lb N rate 75 bu/acre of grain was harvested. In 1997, the unfertilized profi-pea crop got off to a slow start with a dryer than normal April. However, on 11, July 1997 we harvested 900 to 1100 lbs of grain with a whole plot average of 1011 lbs/acre. The 1998 crop of winter wheat averaged 26 bushels in the fertilized plots and 22 bushels in unfertilized plots. Corn yields in 1999 were as high as 140 bushels per acre at the 80 and 100 lb N rates. Warm season grasses (sandbur) are becoming a nuisance. In 2000, roundup ready soybean (maturity group 3) was used to help eliminate the sandbur problem. The soybeans were not fertilized with N because residual N levels were large from fertilization in prior years. A visual response of the soybean was observed. The lowest yields were measured in the 80 and 120 lb N/acre plots (8 bushel/acre). The largest yields were measured in the 0 N-rate plot (13 bushel/acre).

FUTURE PLANS: The crops for the next few years will be dormant seeded winter wheat or spring triticale, Round-up ready corn and dry edible beans or millet. The experiment will continue for another 4 years to evaluate long-term soil C and N changes under high N management and high productivity.

NITROGEN RESPONSE OF SUNFLOWERS IN A DRYLAND ROTATION

M. F. Vigil, J. G. Benjamin, J. Schepers

PROBLEM: The current demand for edible oils has improved the profitability of sunflowers in the Central Great Plains. However, knowledge of sunflower response to fertilizer N in the region is limited. The objectives here are: (i) to measure sunflower N response in a no-till wheat-corn-sunflower-fallow rotation, (ii) to determine N fertilizer recovery of this crop as affected by fertilizer placement method, and (iii) to compare narrow row (20") production with conventional spacing.

APPROACH: Sunflower is planted and fertilized in a split-plot 4-rep experiment. Main plots consist of rotation crop/phase (sunflowers, corn, wheat or fallow). Sub-plots are fertilizer N rates of 0, 30, 60, or 90 lb N/acre. Sunflowers are planted in either 20 or 30 inch rows. A seeding rate of 16,600 seeds per acre is used for both row spacings. In the 20 inch row plots, 2 rows are sprayed at the 5th leaf stage and at the early-bud stage with zinc, copper, manganese and boron. Individual plots are 60 ft by 240 ft in size. Surface and deep placed ^{15}N labeled fertilizer is used to evaluate fertilizer N recovery with soil depth and N placement method.

RESULTS: In 1999, 6 inches of rainfall in August resulted in a significant sunflower yield response to added N fertilizer (see table). This is the first sunflower yield response we have measured in this experiment to fertilizer N. Yields were also significantly greater when planted on 20 inch rows as compared to 30 inch rows. Micronutrients did not significantly increase or decrease sunflower yields. But significantly increased seed oil content. We measured 21% recovery of fertilizer N at the 4 foot depth and 60% recovery from banded N placed 4 inch deep, 4 inch away from the row. We were surprised to measure 50% recovery from fertilizer N placed 2 feet deep.

	1999 Row spacing effects		
N rate	30 inch rows	20 inch no micronutrients	20 inch with micronutrients
lbs/acre	----------1999 Grain yields ---------- (lbs/acre)		
0	1538 (39.2)*	1776 (39.9)	1963 (41.6)
30	2072 (38.0)	2417 (39.3)	2594 (40.4)
60	2090 (37.4)	2682 (37.2)	2556 (38.8)
90	2224 (36.9)	2505 (38.1)	2866 (38.6)

* Values in parenthesis are seed oil contents (%).

In 2000, a dryer than normal summer with low preplant soil water contents we measured less than 300 lbs of grain in our best sunflower plots. No row spacing, N rate, or micronutrient responses were detected in 2000 with either sunflowers or corn. Water was more limiting than these other management factors.

FUTURE PLANS: The experiment will be continued for another 4 years to evaluate long term effects of intensive wheat-corn-sunflower fallow rotations and to continue to evaluate N and row spacing effects on yield.

SOIL CARBON AND NITROGEN CHANGES IN A LONG TERM TILLAGE STUDY

M. F. Vigil, R. A. Bowman, R. L. Anderson

PROBLEM: Winter wheat-fallow remains the dominant cropping system in the Central Great Plains region of the United States. During fallow, weeds are generally controlled using sweep-plow tillage (stubble mulch). Weed control with herbicides is generally too expensive unless a more intensive rotation is adopted. On the other hand, conventional tillage during fallow reduces soil organic matters levels at the soil surface and increases wind and water erosion.

APPROACH: This study was originally established in 1967 by Darryl Smika, and modified by Merle Vigil and Randy Anderson in 1996. In 1967 four weed control strategies during fallow were compared. These were no-till (residual and contact herbicides only), reduce-till (residual herbicides in August after wheat harvest followed by tillage the next summer after residual herbicides had failed), stubble-mulch (sweep-plow managed summer fallow), and a moldboard plow treatment. This core set of plots has been kept since 1967. We have added a four year rotation of wheat-corn-sunflower-summer fallow. This rotation was established to evaluate long term changes in soil Carbon and soil organic matter as influenced by intensive management. The Sunflower will be replaced with round-up ready soybeans in 2001. Other studies of an academic nature have included: a Delta ^{13}C dating of soil organic matter pools, studies to evaluate infiltration and compaction as influenced by long term tillage, and studies to evaluate fungal verses bacterial activity as influenced by tillage.

RESULTS: In general the no-till plots have not produced better than the tilled plots. The moldboard plow plots are less weedy then either the sweep tilled plots and/or the no-till or reduce till plots. The plots that have been exclusively in a wheat-fallow rotation are infested with jointed goat grass and cheat grass. Plots that have had a three year rotation of wheat-corn-fallow are relatively much cleaner with respect to weeds. Soil organic matter levels are being evaluated as a function of tillage and soil depth. The largest difference (as you might expect) is with lower surface organic matter levels in the moldboard plow treatment as compared with the no-till plots. Nearly 15 times more fungal activity is measured in the surface 15 cm of these soils then bacterial activity with no significant differences between tilled and no-till plots.

FUTURE PLANS: Grassy weed pressure was a problem in the wheat-fallow plots and so pea was substituted for winter wheat for a period of 3 yrs. Those weeds appear to be under control and so Spring triticale will be planted in 2001 and then the IMI-wheat will be planted to evaluate its effectiveness as a means to control winter annual grasses in winter wheat. Because of its long term history the experiment has become valuable for looking at long term changes in soil organic matter, total soil N and C and changes in soil tilth at the soil surface. The experiment has been identified as a unique part of a network of long term experimental sites across the United States and Canada. Long term changes in soil surface C and soil tilth is being evaluated across that site network. We would like to keep the experiment going for 8 years in order to complete 2 cycles of the four year rotation.

PUBLICATIONS

Archer, D.W. , J.L. Pickul Jr., M.F. Vigil. 2000. Economics analysis of nitrogen starter fertilizer and rotation effects of soybean quality. Agron. Abstr. Pp.133 Am. Soc. Agron. National meeting, Minneapolis, Minn.

Benjamin, J.G., D.C.Nielsen, M.F. Vigil, R.A. Bowman, R.L. Anderson. 2000. Dryland crop rotation effects on the least limiting water range in eastern Colorado. Agron. Abstr. Pp.314 Agron. National meeting, Minneapolis, Minn.

Bowman, R. A. 1999. Final report to ACDI/VOCA "Soils laboratory improvement" SPECTROLAB for Universidad Tecnica de Oruro (UTO), Facultad Nacional de Ingenieria. 8 pages in English and Spanish.

Bowman, R. A. 1999. Final Report to ACDI/VOCA "Follow-up to soils laboratory improvement-soils laboratory improvement" and "First national soil science congress" for IBTA-Tarija & Congreso Nacional de Suelos. 9 pages in English and Spanish.

Bowman, R.A., M.F. Vigil. 2000. Sulfur and micronutrient changes as a function of dryland cropping intensity. *In Proceedings* Great Plains Soil Fertility Conference. 8:165-170. March 7-8, 2000.

Bowman, R. A., and M. F. Vigil. 2000. Manure P sorption and release in semiarid soils. Innovative technologies for planning animal feeding operations Conference Proc. (ed. M. F. Vigil and L. Pieper, Akron, CO). p. 28-36. Dec. 4-6, Renaissance Denver Hotel, Denver, CO.

Bowman, R. A., J. D. Reeder, and B. J. Wienhold. 2000. Laboratory and field evaluations to assess carbon sequestration. Agron. Abstr. p. 313. Am. Soc. Agron. National Meeting, Minneapolis, MN.

Bowman, R A., and M. F. Vigil. 2000. Phosphorus: What happens in the soil? Colo. Conserv. Tillage Assoc. Proc. 12:65-67. Feb. 8-9, Northeastern Junior College, Sterling, CO

Bowman, R. A., D. C. Nielsen, M. F. Vigil, and R. M. Aiken. 2000. Effects of sunflower on soil quality indicators and subsequent wheat yield. Soil Sci. 165:516-522.

Butters, G.L., J.G. Benjamin, L.R. Ahuja, and H. Ruan. 2000. Bromide and atrazine leaching in furrow- and sprinkler-irrigated corn. Soil Sci. Soc. Am. J. 64:1723-1732.

Jakubowski B.R., M.F. Vigil, J.G. Davis, B. Eghball. 2000. In-situ nitrogen mineralization of manure amended soils. Agron. Abstr. Pp.355. Am. Soc. Agron. National meeting, Minneapolis, Minn.

Jakubowski, B.R., M.F. Vigil, J.G. Davis, and B. Eghball, 2000. In-situ nitrogen mineralization of manure amended soil. *In Proceedings* Great Plains Soil Fertility Conference. 8:122-126. March 7-8 2000.

Kaan, Dennis A. 2000. Crop enterprise cost estimates for 1999 in Northeastern Colorado. 2000 Golden Plains Area Agricultural Handbook. 16pp.

Kaan, Dennis A. 2000. Livestock economics. 2000. Golden Plains Area Agricultural Handbook. 19pp.

Kaan, Dennis A., Don Nitchie. 2000. Forward pricing for wheat producers. Colorado Wheat Production Handbook. 4pp.

Kaan, Dennis A. 2000. Cost-return prospects for wheat. Colorado Wheat Production Handbook. 5pp.

McMaster, G.S., R.M. Aiken, and D.C. Nielsen. 2000. Optimizing wheat harvest cutting height for harvest efficiency and soil and water conservation. Agron. J. 92:1104-1108.

Pickul, J.L. Jr., Carpenter-Boggs, M.F. Vigil, and W.E.Riedell. 2000. Corn soybean yields and soil condition under ridge and chisel-plow tillage in the northern corn belt. *In Proceedings* Great Plains Soil Fertility Conference. 8:244-250. March 7-8, 2000.

Vigil, M.F. (ed.) 2000. Innovative technologies for planning animal feeding operations. proc. workshop USDA-NRCS, SWCS, Denver, CO. 4-5 Dec. 1999. 200 pages.

Vigil, M.F., J.G. Benjamin. 2000. Recovery of deep placed 15N by sunflowers. Agron. Abstr. Pp.277 Am. Soc. Agron. National meeting, Minneapolis, Minn.

ACCEPTED

Nielsen, D.C. 2001. Production functions for chickpea, field pea, and lentil in the central Great Plains. Agron. J. 93 (3):XXX-XXX. (accepted 19 Dec. 2000)

Ruan, H., L.R. Ahuja, J.G. Benjamin, and T.R. Green, 2001. Residue cover and surface-sealing effects on infiltration: numerical similations for field applications. Soil Sci. Soc. Am. J. 65:XXX-XXX (accepted for publication November 15, 2000).

IN PREPARATION

Benjamin, J.G. 2001. Predicting unsaturated hydraulic conductivity from the Gregson-Hector-McGowen one-parameter water desorption model. Soil Sci. Soc. Am. J. (Submitted)

Benjamin, J.G., D.C. Nielsen, M.F. Vigil, R.A. Bowman and R.L. Anderson. 2001. Dryland crop rotation effects on the least limiting water content range in eastern Colorado. Plant and Soils.

Bowman, R.A., D.C. Nielsen, M.F. Vigil, and R.M. Aiken. 2000. Does sunflower rotation reduce surface crop residue protection, soil quality, and subsequent winter wheat yields? Submitted to Soil Sci.

Bowman, R.A., and M.F. Vigil. 2000. Adsorption, movement, and transformation of manure P and organic P in soils. To be submitted to Soil Sci. Journal.

Bowman, R. A., and R. L. Anderson. Conservation reserve program effects on soil organic carbon, and preservation when converted back to cropland in Northeastern Colorado. Submitted to J. Soil and·Water Conserv.

Bowman, R. A. Organic P extractability in beef, chicken, dairy, and pig manures. To be submitted after local review to Soil Sci. Soc. Am. J.

Bowman, R, A., M. F. Vigil, D. C. Nielsen, and J. G. Benjamin. Organic carbon sequestration in dryland cropping systems. To be submitted after local review to Soil Sci. Soc. Am. J.

Burgener, P.A., Kaan, D.A., O'Brien, D.M., Feuz, D.M. 2000. An economic analysis of intensive dryland cropping systems for the central Great Plains. Submitted for presentation at Western Agricultural Economics Association Meetings, 2001.

Carpenter-Boggs, Lynne, J.L. Pikul Jr., M.F. Vigil and W.E. Riedell. 2000. Soil nitrogen mineralization influenced by crop rotation and N fertilization rate.

Johnson, A.M., D.L. Tanaka, P.R. Miller, S.A. Brandt, D.C. Nielsen, G.P. Lafond, and N.R. Riveland. 2001. Oilseed crops for semiarid cropping systems on the northern Great Plains. (submitted to Agron. J. on 22 Sep 2000).

Ma, L., D.C. Nielsen, L.R. Ahuja, K.W. Rojas, J.D. Hanson, J.R. Kiniry, and J.G. Benjamin. 2001. Modeling corn responses to water stress under varying irrigation levels in the Great Plans. (submitted to Trans. ASAE., reviewed and in revision process).

Nielsen, D.C., L. Ma, and L.R. Ahuja. 2001. Simulating soybean water stress effects with the Root Zone Water Quality Model. (Submitted to Agron. J.on 28 Aug 2000).

Nielsen, D.C. 2001. Enhancing water use efficiency. In R. Lal (ed.) The Encyclopedia of Soil Science. Marcel Dekker, New York. (Submitted 15 Feb 2001).

Nielsen, D.C. 2001. Kenaf forage yield and quality under varying water availability. (in preparation for Crop Sci.).

Shaffer M., M.F. Vigil, R.L. Anderson. 2000. Simulation crop residue decay on the soil surface testing and validation.

Vigil, M.F., D. C. Nielsen, R.L. Anderson. 2000. Assessment of the nitrogen contribution of annual legumes to winter wheat in a legume-green fallow rotation.

Vigil, M.F., R.L. Anderson. 2000 Wheat and sunflower residue loss as affected by reduce-till and no-till summer fallow.